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W. C. EBAUGH

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GRANVILLE, OHIO

DECEMBER, 1938

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JOURNAL OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY

The entire file of volumes 1 to 13 was destroyed by fire; no publications issued prior to 1907 are now available. Volumes 14 to date may be obtained from the editor at $2.00 per volume, with the exception of volume 15, the price of which is $1.00. Separate parts, as listed below, may be purchased at the prices indicated.

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- Pre-Wisconsin drift in the Finger Lake Region of New York; F. Carney. 16 pp., 4 figs.
- An esker group south of Dayton, Ohio; Earl R. Scheffel. 15 pp., 6 figs.
- Wave-cut terraces in Keuka Valley, older than the recession stage of Wisconsin ice; F. Carney. 12 pp., 2 figs.
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- State geological surveys and practical geography; F. Carney. 6 pp.

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- Studies on Babbitt and other alloys; 10 pp. J. A. Baker.
- A stratigraphical study of Mary Ann Township, Licking County, O. 28 pp., 15 figs. F. Carney.
- Significance of drainage changes near Granville, Ohio; Earl R. Scheffel. 17 pp., 2 figs.
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- The development of the idea of glacial erosion in America; F. Carney. 10 pp.
- Preliminary notes on Cincinnatian fossils; Aug. F. Foerste. 20 pp., 1 plate.
- Notes on Spondylomorum Quaternarium Ehrenb; M. E. Stickney. 5 pp., 1 plate.
- The reaction to tactile stimuli and the development of the swimming movement in embryos of Diemyctylus torsus Eschscholtz; G. E. Coghill. 21 pp., 6 figs.
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- The abandoned shorelines of the Oberlin Quadrangle, Ohio; Frank Carney. 16 pp., 5 figs.

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- Standardization of well water in the vicinity of Granville, Ohio; Lily Bell Sefton. 5 pp.
- Chapters on the geography of Ohio; F. Carney.
  - Transportation; 11 pp.
  - Economic mineral products; 47 pp.
  - Glaciation in Ohio; 43 pp.

Articles 8–12, pp. 233–346; April, 1911.....$0.75
- The abandoned shorelines of the Vermilion Quadrangle, Ohio; F. Carney. 12 pp., 2 figs.
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- The Mercer limestone and its associated rocks in the Newark-Zanesville region; Clara G. Mark. 47 pp., 2 plates, 5 figs.
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- The Swasey Observatory, Denison University; Herbert C. Wilson. 5 pp., 4 figs.
- The contribution of Astronomy to general culture; Edwin B. Frost. 12 pp.
- The geological development of Ohio; F. Carney. 15 pp.
- The relief features of Ohio; F. Carney. 13 pp., 1 fig.
- Geographic conditions in the early history of the Ohio country; F. Carney. 20 pp.

VOLUME 17

Articles 1–4, pp. 1–201; March, 1912.....$1.50
- A geographic interpretation of Cincinnati, Ohio; Edith M. Southall. 16 pp.
- Strophomena and other fossils from Cincinnatian and Mohawkian horizons, chiefly in Ohio, Indiana, Kentucky; Aug. F. Foerste. 158 pp., 18 plates.
- Population centers and density of population; F. Carney. 15 pp.
- The climate of Ohio; F. Carney. 9 pp.

Articles 5–7, pp. 203–246; March, 1913.....$0.50
- The twenty-fifth anniversary of the founding of the Denison Scientific Association. 2 pp.
- The foundation of culture; C. Judson Herrick. 14 pp.
- Drainage changes in the Moots Run area, Licking County, Ohio; Harmon A. Nixon and Dexter J. Tight. 11 pp., 1 fig.
- Some pre-glacial lake shorelines of the Bellevue Quadrangle, Ohio; F. Carney. 16 pp., 3 figs.

Articles 8–10, pp. 247–373; March, 1914.....$1.00
- Lorraine faunas of New York and Quebec; Aug. F. Foerste. 93 pp., 5 plates.
- A comparative study of circular and rectangular Imhoff tanks; Theodore Sedgwick Johnson. 26 pp.
- Geographic factors in the establishing of the Ohio-Michigan boundary line; Constance Grace Eirich. 7 pp.

Articles 11–14, pp. 375–487; September, 1914.....$1.00
- A method of subdividing the interior of a simply closed rectifiable curve with an application to Cauchy's theorem. F. B. Wiley and G. A. Bliss. 14 pp., 3 figs.
- The influence of glaciation on agriculture in Ohio; Edgar W. Owen. 4 pp, 1 fig.
- The Locust Grove Esker, Ohio; James D. Thompson, Jr. 4 pp., 1 fig.
- Notes on Agelacrinidae and Lepadocystinae, with descriptions of Thresherodiscus and Brockocystis; Aug. F. Foerste. 38 pp., 6 plates.

VOLUME 18

Articles 1–3, pp. 1–284; December, 1915.....$1.75
- Proceedings of the inauguration of President Chamberlain. 54 pp.
- Denison University presidents; William Hannibal Johnson. 5 pp.
- The fauna of the Morrow Group of Arkansas and Oklahoma; Kirtley F. Mather. 226 pp., 2 figs., 16 plates.

Articles 4–7, pp. 285–378; December, 1916.....$1.00
- Notes on Cincinnatian fossil types; Aug. F. Foerste. 71 pp., 7 plates.
- The shorelines of glacial lakes Lundy, Wayne, and Arkona, of the Oberlin Quadrangle, Ohio; Frank Carney. 6 pp. 1 fig.
- The progress of Geology during the period 1891–1915; Frank Carney. 8 pp., 4 figs.
- The abandoned shorelines of the Ashtabula Quadrangle, Ohio; Frank Carney. 24 pp., 4 figs.

VOLUME 19

Articles 1–4, pp. 1–64; April, 1919.....$0.75
- Echinodermata of the Brassfield (Silurian) formation of Ohio; Aug. F. Foerste. 30 pp., 7 plates.
- America's advance in potash production; W. C. Ebaugh. 14 pp., 2 figs.
- The use of outline charts in teaching vertebrate paleontology; Maurice G. Mehl. 3 pp., 1 fig., 4 plates.
- Some factors in the geographic distribution of petroleum; Maurice G. Mehl. 9 pp., 2 plates.

Articles 5–8, pp. 65–146; September, 1919.....$0.75
- Notes on Isotelus, Achrolichas, Calymene and Encrinurus; Aug. F. Foerste. 18 pp., 6 plates.

JOURNAL

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W. C. EBAUGH

VOLUME XXXIII

1938

GRANVILLE, OHIO

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DENISON SCIENTIFIC ASSOCIATION

Organized April 16, 1887

REPORT OF THE PERMANENT SECRETARY FOR THE YEAR 1937–1938

Officers of the Association were as follows:

R. H. HOWE, *President*
CHARLOTTE RICE, *Vice-President*
W. C. EBAUGH, *Permanent Secretary and Editor*
A. C. LADNER, *Recording Secretary and Treasurer*
L. E. SMITH, *Librarian*

In accordance with its usual custom the Denison Scientific Association held meetings alternate Tuesday evenings in the Physics Lecture Room of Barney Science Hall as follows:

October 5

NUCLEAR PHYSICS. LEON E. SMITH.

The more successful physicists have been in explaining the molecule and the atom and the properties of these building blocks of nature, the more inquisitive men have become concerning the elementary structure of the atom itself. About thirty years ago evidence began to point toward our so-called "nuclear structure" of the atom, and the next few years added weight to these hypotheses. Now we find the beginnings of some satisfying explanations of the methods of putting the nucleus together. There is enough knowledge and experimental technique at hand to change one element into another one having entirely different chemical and physical properties. There has also been added one new element to our list, which up to this time was regarded as closed at the ends. There is much activity in the field of nuclear physics at the present time, new and powerful techniques are being exploited and it is safe to say that

no one knows when or what important new deduction may appear. The rôles of electrons, protons, positrons, alpha particles, beta particles, and neutrons in building up atoms of ordinary elements and their isotropes were discussed in detail.

October 19

THE ECLIPSE AT AK BULAK. WALLACE R. BRODE (Ohio State University).

Imagine a scientific expedition for which 13 men and 9 women traveled more than 7000 miles from Boston, U. S. A., to Ak Bulak, Central Asian U. S. S. R., taking with them tons of equipment and thousands of dollars worth of instruments—all for the sake of making a few photographs during the scant 117 seconds, *weather permitting*, when the light of the sun was cut off by the passage of the moon between earth and sun on June 19, 1936! Dr. Brode, who was a member of the Harvard-M. I. T. Solar Eclipse Expedition referred to above, related some of the experiences of the scientific workers, the results obtained, and the contributions they made to our knowledge of the most prominent heavenly body, the sun. The lecture was illustrated fully.

November 2

THE ARTIST TALKS ABOUT COLOR. HORACE KING.

The physicist first analyzed color with a glass prism. The chemist made color with organic and metallic derivatives. The psychologist has observed and measured the effect of color on human beings.

Before all this happened, however, in fact, 10,000 or more years before, the artist talked about color. He then decorated his cave, his body, his wife, his children, and his few weapons, tools and utensils with his new-found medium. Today the artist is still talking about color, but like his speech, his color is so much more complex that it is time for him to recognize the physicist, chemist, and psychologist as collaborators in the business of organizing color into theories and harmonies by which all men can live in chromatic peace and contentment.

Colored slides and charts were used to illustrate the discussion of the physical properties of colors, the relation of the color wheel to the spectrum, and the development and application of some new color harmonies.

November 16

CRIME DETECTION. C. G. L. YEARICK (Newark, Ohio).

From his six years' experience as the prosecuting attorney of Licking County and as an instructor in the Police School of Ohio State University, Colonel Yearick explained and demonstrated the use of finger prints, forensic ballistics or firearms' identification, detectors for deception techniques, and the lie detector. The last named demonstration was conducted by Professor Higley of the Department of Psychology at Ohio State University.

November 30

CHANGING THE GEOGRAPHIC LANDSCAPE. F. J. WRIGHT.

A study of some of the major projects now under way, which materially modify both the physical and the cultural landscape, was described. The following were considered: proposed Florida ship canal, Passamoquoddy tidal project, Tennessee Valley Authority, soil erosion and conservation, gigantic dams such as the Grand Coulee, and the Shelter Belt. Not primarily an appraisal of the value of these projects, but observations on their geographic effects, formed the basis of the discussion.

December 14

GROWTH HORMONES IN PLANTS. M. E. STICKNEY.

It is well known that hormones play a most important rôle in the life and activities of animals. The hormone produced by the thyroid gland, for example, determines the character of growth and development of the body; and upon it will depend whether an infant will develop normal brains or become an idiot.

In recent years it has been found that plants, as well as animals,

produce hormones which play an important part in their growth or in prevention of growth. Although our knowledge regarding plant hormones is as yet imperfect and meagre, we are beginning to understand why plants grow toward a lighted window, or why, when the main axis of a tree is cut off, a lateral branch will grow up to take its place. It may not be safe to predict where a more complete knowledge of plant hormones may lead us in the future control of growth in cultivated plants. We wonder how it would seem to pick strawberries off trees. Methods for "breaking dormancy" and altering plant habits were presented.

January 11

FOUR NEIGHBORS. CHARLOTTE RICE.

The motion picture told in a vivid way the problems of four twelve year old school mates, Patsy O'Hara, Hyman Markovitz, Angelo Catabria, and Frank Jones, and their families.

The boys were sent by the school principal to the Judge Baker Guidance Center which, after months of treatment, found a helpful solution for each of the problems. The picture illustrated the fact that families in *all* racial groups and with every sort of economic background face problems in the children's lives which the guidance center can help. The four situations chosen for presentation are a conduct problem, a vocational problem, a personality problem, and a family conflict problem.

February 1

THE HEART OF MATHEMATICS. CHOSABURO KATO.

Mathematics in its higher branches is so remote from our usual idea of what constitutes that subject that it no longer seems the same. In order to appreciate some of the fundamental truths of this subject, however, it is not altogether necessary to go into the extended manipulation of mathematical symbols, which are usually too complicated and difficult for the uninitiated to understand. A short path to the heart of mathematics through the field of Projective Geometry was shown.

February 15

THE GEORGE WASHINGTON BRIDGE. C. S. Ades.

This bridge is one of the greatest triumphs of modern engineering. At the time of its erection, its main span was twice as long as that of any suspension bridge previously built. Despite its size, however, its design and construction are typical of similar types of bridges, and of the general methods employed by engineers. Without going much into technical details, an idea of these engineering methods was given by explaining and illustrating the design and construction of this magnificent structure.

March 1

THE TRENDS OF SOCIETY. A. W. Lindsey.

From the biological point of view man is not a fundamentally social organism, but is social for expediency. In other words, he is intelligent enough to see the value of social organization. There are still many characteristics of the solitary animals in his makeup, however, that clash with his adjustment to other men. We are now witnessing the results of this clash in many parts of the world. The underlying causes are biologically clear, though the cures depend on your political faith. This discussion was diagnostic, not therapeutic.

March 22

MEASURING MOLECULES. W. A. Everhart, John Brauning and Horace Hamlin.

Molecules of matter are submicroscopic in size. Although they cannot be seen, they may nevertheless be measured as to average diameters, lengths and volumes. The methods employed are diverse in nature, and all are indirect, yet they give excellent checks. Knowledge gained from such measurements has practical value in applied chemistry and physics.

One of these indirect ways of estimating the size and shape of the molecules of a fatty acid was demonstrated, showing how molecules may be measured by means of a meter stick.

April 12

AMBROSE SWASEY. FREEMAN D. MILLER.

"From a New England heredity, environment and training, Ambrose Swasey derived qualities of character that have filled his life with those distinguished services for which his fellow engineers confer upon him the Hoover Gold Medal. As technical success and material prosperity crowned honest and intelligent labor, Mr. Swasey grew in moral and spiritual stature, and extended his influence into a long life of distinguished service to industry, engineering, science, research, his church, education, and public affairs. With all of these he shared his fortune as well as his intellect and the vigor of his personality.

"The list of his honors is long and impressive, but on it is none that describes him so well as that bestowed by a group of personal friends—Knight of the Kindly Heart."

(From the text of the formal presentation of the Hoover Gold Medal by the National Engineering Societies, December 2, 1937.)

The long and fruitful career of Mr. Swasey as scientist, designer and builder of some of the world's most famous telescope mountings, benefactor of Denison University in endowment and beautification of grounds, and as donor of its Swasey Observatory and Swasey Chapel, were outlined.

April 26

THE PREDICTABILITY OF THE LEARNING REACTION. T. A. LEWIS AND GEORGE KNOX.

From more than one angle, psychologists have tried for a long time to figure out the nature of learning. In learning, behavior is modified, but just what has happened back of the scenes to account for the different activity of the individual is not fully agreed upon. The changed conduct of the individual, it is generally agreed, must involve some transformation in the nervous system; but there is not much to be made of this fact to the end of predicting the course of a learning reaction, because the nervous system is too much of an unknown land. For this reason, changes in behavior are studied largely in terms of

explicit (outward) occurrence. Much has been found out about the learning process through the study of subhuman animals—the chick, the rat, the dog, the ape, etc. Things found out by the observation of these simpler types of behavior have helped considerably in understanding the more complex behavior of human learners. The predictability, it is safe to say, rests on our knowledge and control of the stimulating situation, including both inner and outer stimuli which jointly determine the learner's reactions. The doctrines of the two schools of learning, *i.e.*, Associationism and Structuralism, and their use in explaining the learning reaction, were explained in broad outline.

May 10

SEEING THE UNIVERSE.

A silent movie; its five reels provided views of the "world beyond" through the world's largest telescopes. Its five reels were titled, (1) Seeing the Sun, (2) Going to the Moon, (3) From Mercury to Mars, (4) Jupiter, Saturn, and Beyond, and (5) The Pathway of the Gods. A lecture and description of the astronomical objects and events accompanied the film.

Three numbers of our JOURNAL OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY were issued, viz.:

Vol. XXXII, Articles 3-7, pp. 133-207, August, 1937.

Science and the College (Commemoration Address); Carey Croneis. 12 pp.

Our Endowment (Commemoration Address); C. Judson Herrick. 9 pp.

Science—Man's Liberator (Commemoration Address); William E. Wickenden. 10 pp.

The Application of Physics to Modern Hydrographic Surveying; (Commemoration Address); Herbert Grove Dorsey. 22 pp. 10 plates.

An Annoted Check-list of Birds Recorded at Granville, Licking County, Ohio; Ward M. Klepfer and William J. Taylor. 21 pp. 1 plate.

Vol. XXXII, Article 8, pp. 209-337, December, 1937.

Upper Carboniferous Crinoids from the Morrow Subseries of Arkansas, Oklahoma and Texas; Raymond C. Moore and Frederick N. Plummer. 106 pp., 37 figs., 5 plates.

Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION. 10 pp.

Vol. XXXIII, Article 1, pp. 1–60, April, 1938.
The Telescopic Alidade and the Plane Table as used in Topographic and Geologic Surveys; Kirtley F. Mather and Bradford Washburn. 60 pp., 19 figs.

From the above it will be seen that the DENISON SCIENTIFIC ASSOCIATION entered upon its second half-century strong in its program, active in its publication of worth-while scientific papers, and stimulating to the intellectual atmosphere of the University. It bespeaks the continued support of trustees, faculty, alumni and students.

Respectfully submitted,

W. C. EBAUGH, *Permanent Secretary and Editor*

THE USE OF FRAGMENTARY CRINOIDAL REMAINS IN STRATIGRAPHIC PALEONTOLOGY

RAYMOND C. MOORE

Received October 21, 1938; published, January 14, 1939

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INTRODUCTION

Fossils have value in stratigraphic paleontology in proportion to the extent and precision with which they may be used in defining age equivalence of the containing rock strata. Generally speaking, a particular kind of fossil has greatest practical usefulness in stratigraphic studies if it is (1) confined to a definite part of the geologic column, (2) widely distributed geographically, (3) abundantly represented by individuals, and (4) identifiable readily and reliably. It makes little difference whether the fossil is the remains of an animal or a plant, or whether it belongs to one phylum rather than another. Thus, special attention may be directed to graptolites or trilobites, brachiopods or

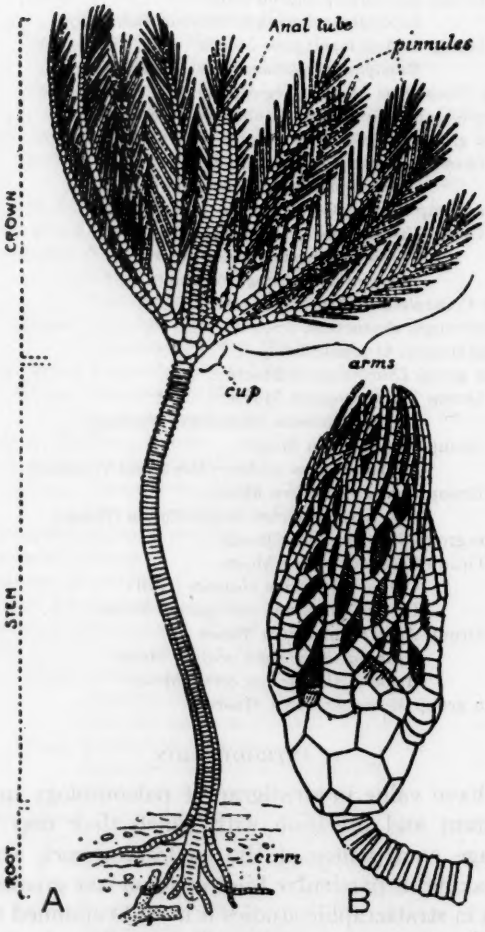


FIG. 1. SKELETONS OF CRINOIDS SHOWING DIFFERENT SORTS OF OSSICLES IN NORMAL POSITIONS AS JOINED TOGETHER

A, Reconstruction of the Silurian crinoid *Botryocrinus decadactylus*. *B*, Crown and portion of the stem of *Cyathocrinus multibrachiatus*, Lower Carboniferous. (After Bather.)

bryozoans, ammonoids or fusulinids, as these happen best to serve the purpose of zonation and correlation.

Crinoids are invertebrates of complex structure and varied form that are well known to have usefulness as guide fossils in some areas and in certain parts of the geologic column. Most species of crinoids have a very narrow stratigraphic range. In some cases, crinoids from widely separated outcrops, even from different continents, are practically identical. Almost any specimen that is reasonably complete can be identified with moderate ease and certainty (see Figure 1). These are highly desirable attributes from the view point of stratigraphic paleontology. A factor that limits usefulness of crinoids in defining and tracing faunal zones, however, is general scarcity of specimens that are sufficiently complete for identification. Exceptional are the horizons and localities that yield fairly numerous crinoid crowns with a portion of attached stem, such as Lower Devonian rocks near Litchfield, N. Y.; Lower Carboniferous beds near LeGrand and Burlington, Iowa, Crawfordsville, Ind., Tournai, Belgium, and Invertiel and Roscobie, Scotland; Upper Carboniferous strata at Kansas City, Mo., and near Moscow, Russia; and Permian deposits in Timor, Dutch East Indies.

In strong contrast to general scarcity of fairly complete crinoid cups and crowns is an abundance of fragmentary crinoidal remains in many rock formations. Dissociated plates or segments of the crinoid skeleton, called ossicles, are a chief constituent of numerous marine deposits of middle and late Paleozoic age, and they are common fossils in very many additional deposits, distributed over large areas (see Figure 2). If characters of the ossicles, or some of them, differ from one horizon to another, in a manner corresponding to changes in species of crinoids as determined from study of articulated specimens, the usefulness of this group of fossils in stratigraphic research should be increased largely. This is a reasonable presumption, and extensive collection of crinoid ossicles from many upper Paleozoic horizons in the Mid-Continent region of the United States shows conclusively that they do have value in stratigraphic paleontology. Implication that previous workers have overlooked the

possible usefulness of fragmentary crinoidal remains is not intended in making these observations, for there are published records of at least some successful efforts to employ distinctive types of crinoid ossicles in stratigraphic work. On the other hand, no attempt appears to have been made in the direction of

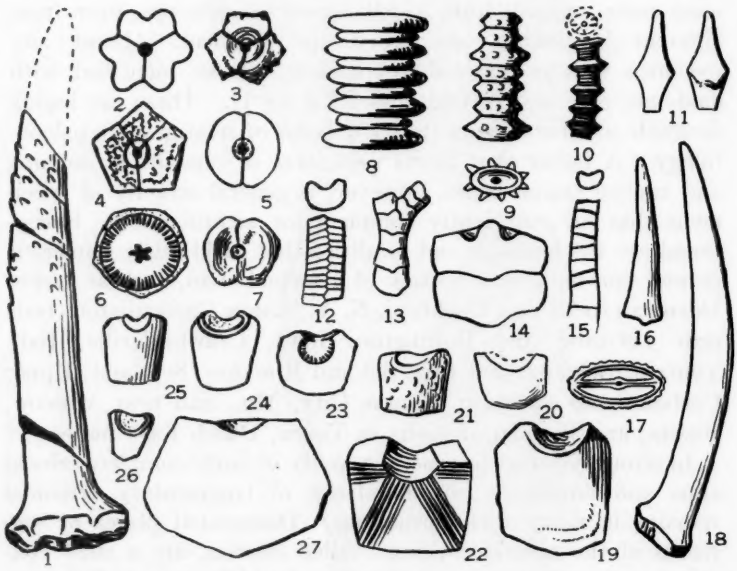


FIG. 2. SKETCHES OF A MISCELLANEOUS ASSORTMENT OF MISSISSIPPIAN (LOWER CARBONIFEROUS) CRINOID OSSICLES, ×1

Kinderhook, *24, 26*; Burlington, *2–4, 6, 9, 10, 13, 14, 16, 19–23, 25, 27*; Keokuk, *1, 8, 12, 15, 17, 18*; Warsaw, *5*; Chester, *7, 11*. Types of ossicles represented according to divisions: Columnals, *8–10, 17*; Apicals, *2–7*; Facetals, *19–27*; Tegminals, *1, 11, 16, 18*; Pinnates, *12–15*. (Prepared by Lyman Terry).

systematic study of crinoid ossicles. This paper deals first with the problem of scientific designation of the different kinds of ossicles, as required for purposes of description and recording in lists, and then offers characterization of morphologic features that are observed in a number of classes of ossicles.

CLASSIFICATION AND DESIGNATION OF CRINOID OSSICLES

A crinoid ossicle may consist of a segment of the stem, a portion of one of its side branches (cirri), a plate of the dorsal cup belonging to one of four or five categories (infrabasal, basal, radial, anal, interradial), an element of the tegmen, including possibly specialized grooved or spinous plates of the anal sac, a segment (brachial) of one of the arms, or a fragment of its branchlets (pinnules). The number and variety of these skeletal elements is large, but with only a few exceptions any type of ossicle can be assigned properly to its general place in the skeletal organization. Stem segments can be differentiated from brachials, infrabasals or basals from radials, and anal sac spines from primibrach spines. Peculiarities in outline often make it possible to identify individual plates, such as the posterior basal, right posterior basal, right and left posterior radials, and radianal. The lowermost segment of an arm can be recognized in many instances, but the position of separated brachials belonging to other parts of the arms is rarely determinable very exactly. Corresponding parts of different genera and species of crinoids resemble one another more or less closely, and in some cases it is entirely impossible to distinguish certain of these corresponding elements.

A natural first step in the study of crinoid ossicles, such as is represented in any field collection of them, is classification according to structural position in the crinoid skeleton. Thus, all stem segments are brought together in one group, radial plates in another, basals in a third, and so on.

The next step is presumably a separation of the different kinds of plates occurring in each group. Each of these probably represents some individual species of crinoid, or a group of species in which the particular type of ossicle under consideration happens to be essentially the same for all.

Question must now be raised as to the nature of real objectives in the study and methods of reaching them. If it is necessary to identify the generic and specific assignment of an ossicle in order to catalog and use it in stratigraphic work, there must be some fairly definite distinguishing peculiarity of the ossicle or

identification fails. Experience shows that although some crinoid ossicles can be recognized with reasonable assurance as to generic, or perhaps both generic and specific identity, a majority of these fossil remains cannot be identified thus definitely. Even so, it is observed in many instances that such plates of more or less indeterminable character differ from one horizon to another. In order to make use of these observations we must define the distinguishing features and find means to designate respective ossicles in a manner that will serve practical ends, according with biologic classification and nomenclature, or at least not conflicting with them. This is the problem.

Two divergent courses of general procedure are to be considered.

Designation of Ossicles based on Recognition of Complete Crinoid

From the study of ossicles we may seek recognition of genera and species of crinoids and attempt to designate each ossicle by the name of the whole crinoid from which it came. As has been indicated, this can be done satisfactorily in a fraction of cases, identification being supported by comparison of a given plate with the corresponding element in a complete crinoid specimen. This naturally applies only to ossicles of known genera and species (see Figure 2).

In the case of undescribed species, reliable reconstruction of the dorsal cup can sometimes be made from dissociated plates, provided there is reasonable certainty, as indicated by peculiarities of ornamentation or the like, that different categories of plates belong together. The reconstructed crinoid may be identified generically and given a specific name. Subsequently, any individual ossicle corresponding to one of those in the newly recognized species may be recorded by the name given to the reconstructed cup.

If ossicles cannot be identified by comparison with any known species or assembled to show the character of a new species, they must either be discarded or assigned to a genus and species that is defined only by the observed characters of a very small fraction

of its component ossicles. Such procedure suggests effort to indicate a genus and species of mammal on the basis of a single one of its bones. Even though a paleontologist is sure beyond doubt that a given crinoid ossicle belongs to an undescribed species, it is right that he should hesitate to propose a name for this species and to describe it on the basis of a single fragment. Probably he must make a very uncertain guess as to generic assignment, and almost inevitably such practice would lead to unending confusion.

We may conclude that it is proper and desirable to make all possible use of crinoid ossicles in determining the character of crinoid genera and species, in some cases basing recognition of new forms largely or entirely on material of this sort, but it is not possible to make general use of ossicles in recognizing genera and species of the whole crinoids from which they were derived. Accordingly, it is not practicable to attempt classification and designation of crinoid ossicles in terms of genera and species representing old and new forms of whole crinoids.

Designation of Ossicles as Independent Units

Another line of attack is to treat each variety of crinoid ossicle as an essentially independent unit, without special reference to the generic and specific identity of the organism of which it was once a part. Very obviously, it is possible to define satisfactorily the characters of a distinctive type of stem or anal sac plate and to record the occurrence of this fossil in a particular rock layer, without knowing the generic and specific name of the whole crinoid. It is necessary, however, to designate each variety of ossicle in a manner that will serve to distinguish it as an entity. There are hundreds of different kinds, and these are classifiable in groups that also call for some sort of exact designation. Whatever means of designation are deemed practically most useful, nomenclature must be based on the concept of ossicles as independent units.

Consideration of the manner in which the groups and individual types of ossicles may be designated, holding in the background the fact that they are dissociated parts of organisms, suggests

comparison with practice in paleobotany. Here, different generic and specific names have been given, respectively, to the leaves, trunk, fruiting organs, and roots of a single plant. Likewise, different genera and species of conodonts, as now defined, surely represent a single animal. If a certain type of radial plate among crinoid ossicles,—for example, one with a steeply inclined facet that is narrower than the greatest width of the plate,—were designated as a generic unit and different varieties of this type were recognized as species, treatment of this group of fossils would be analogous to that employed for classification and nomenclature of fossil plants and conodonts. A significant difference may be noted in comparing nomenclature of crinoid ossicles with that of conodonts, certain types of sponge spicules, holothurian ossicles, and some other fossil remains. This lies in the possibility of discovery at any time of a complete specimen of the crinoid to which the radial plate or other part belongs, whereas it is reasonably certain that these other fossil remains will never be associated according to relationship as parts of complete organisms, except in some very unusual instance. Accordingly, nomenclature of crinoid ossicles in terms of so-called genera and species that are based on characters of individual plates would be much less stable than the same procedure as applied to such fossils as conodonts. All sorts of vexatious difficulties would appear. Suppose a "genus" of radial plates is erected to contain forms like the example mentioned above, and then that discovery is made of the whole crinoid to which the genotype "species" belongs. This would invalidate the radial plate generic name because it had been shown to be synonymous with the genus represented by the complete crinoid, and a new radial plate name would need to be coined for remaining "species" of the discarded "genus," for these would not necessarily go along with the genotype. Without further elaboration of such troubles, the conclusion seems inescapable that effort to apply rules of zoological nomenclature to crinoid ossicles, treated as independent units, would lead to great confusion. It is not practicable.

Fortunately, an alternative method of handling that seems

fitted to serve all desired ends is possible. This is the adoption of a *classification and scheme of designation that purposely are made entirely distinct from procedures under the rules of zoological nomenclature.* Let division of crinoid ossicles be made into such large and small groups as suits requirements for differentiation in description and stratigraphic use. If these classificatory units are designated in a manner that cannot be construed to call for application of the zoological rules, there will be no conflict with these rules and difficulties that otherwise appear to be unavoidable are obviated. Such a solution to the problem of dealing with fragmentary organic remains among fossils has been advanced by Croneis.[1]

Proposed Method of Designation for Crinoid Ossicles

The first needful and natural category in classification of crinoid ossicles is that based on structural position in the skeleton of the whole organism. This refers to such groups as columnals (stem segments), all kinds considered together, or radials, or brachials. Each division of this order comprises many subordinate groups, which, in turn, contain varying numbers of forms having certain features in common but differing in others. The classificatory designation of these divisions of different rank seems intrinsically unimportant, provided that such terms as phylum, order, genus, and species are not used, for use of these is established in ordinary zoological nomenclature. Croneis has suggested the appropriateness of names for subdivisions of the Roman army,—exercitus, legio, cohors, manipulus, centuria, and miles. This is acceptable in theory, but paleontologists may be excused for preferring to avoid the burden of learning a set of unfamiliar classificatory terms unless definite need for them is established. It seems practicable and sufficient in the present work to adopt such designations as *Division*, for broadly inclusive assemblages of the first order; *Main Group*, for a less inclusive

[1] Croneis, Carey; Dual classification in paleontology: Paleontological Soc. Abstracts, Washington meeting, p. 70, 1937; Utilitarian Classification for Fragmentary Fossils, Jour. Geol., Vol. XLVI, No. 7 (1938), pp. 975-984.

assemblage of the second order; *Group*, for an assemblage of the third order; and *Section*, for an assemblage of the fourth order.

Names for Assemblages of Higher Orders.—Statement has already been made that classification of crinoid ossicles calls almost inevitably for a primary segregation of morphologically corresponding elements, such as stem fragments, arm segments, and the like. These are assemblages of the first order. It seems best to adopt names for these that are derived from the vernacular, for convenient common use, but at the same time the names in various ranks of the formal classification may properly be derived from Greek. Thus, columnals of all sorts may be assembled under the designation Division *Crinostyli* (from κρινον—crinoid, στυλος—stem), and names for other first order assemblages of crinoid fragments are readily devised.

Main groups and groups within each division are defined on various characters that may be indicated more or less fully in selected names of classic origin, but there are few instances in which assemblages of these orders do not also transgress boundaries of accepted zoological classification. First study of the problem of nomenclature led to the conclusion that main groups in each division might be indicated satisfactorily by letters (as *Columnals-A*, *Columnals-B*, and so on) and that groups might be specified by adding letters of the Greek alphabet (as *Columnals-A-alpha*, *Columnals-A-beta*, and so on), but discussion of this plan with friends among zoologists and paleontologists has resulted in discarding it. Merits of such a scheme lie chiefly in its radical departure from methods of nomenclature that are admissible under the Zoological Rules, thereby making most evident the intended avoidance of concepts of families, genera, and species as generally understood. Defects are the lack in such terms of any indication of characters used in classification, difficulty in differentiating these assemblages without constant reference to original definitions, and a probable disinclination on the part of paleontologists generally to accept such apparently artificial and unfamiliar modes of designation. Finally, it is judged that although the treatment deemed necessary in order to utilize fragments of crinoids in stratigraphic paleontology differs from

ordinary procedure in classification and description of fossils, there is a provision for acceptable handling of our problem without departing from the zoological rules or deviating widely from universal practice in nomenclature of fossils. This provision is found in a recommendation that accompanies Article 8 of the International Rules:

Certain biological groups which have been proposed distinctly as collective groups, not as systematic units, may be treated for convenience as if they were genera, but they require no type species. Examples: *Agamodistomum*, *Amphistomulum*, *Agamofilaria*, *Agamomermis*, *Sparganum*.

The divisions, main groups, groups, and sections of the classification of crinoidal remains, as here introduced, are "proposed distinctly as collective groups, not as systematic units," and although the various names in this case refer to fragments rather than assemblages of whole organisms, it seems proper to follow the plan of nomenclature that is familiar in systematic paleontology.

Names for Assemblages of Lowest Order.—Individual kinds of crinoid ossicles, distinguished by all observable characters, may represent a particular species of crinoid, known or unknown. If two or more species of whole crinoids contain ossicles that are indistinguishable from one another when found as separate fragments, these will naturally have to be referred to the same lowest order assemblage, and the usefulness of the zoologically composite assemblage for purposes of stratigraphic study will depend on the distribution of the different crinoid species. Should they occur in the same bed or zone but not elsewhere, the ossicles from them may be expected to have similar distribution and to be useful because of narrow stratigraphic range. If the indistinguishable ossicles derived from different species in different zones are placed in the same lowest order assemblage, this must be accepted as limiting the usefulness of the assemblage or at least affecting paleontologic interpretation. In any case, there is need for a name that may be applied to this unit, in combination with the name of the next higher order assemblage to which it belongs. No objection is seen to use of descriptive

or dedicatory Latinized words for the lowest order assemblages, just as in the names for species in systematic paleontology, but it should be borne in mind that these units among segregations of ossicles may or may not correspond to single species of whole crinoids and that each lowest order assemblage of ossicles is at least theoretically a "collective group."

Classification of Crinoid Ossicles

Major assemblages among crinoid ossicles are to be defined on the basis of position in the whole skeleton and on such morphologic characters as may be seen in dissociated segments or groups of a few ossicles that remain joined together.

A logical first division may be made between ossicles of the stalk and those of the crown. Segments of the stem or stalk are readily recognized in most cases, and I propose to class them under the designation Division *Columnals*. Assignable here are all parts of the stem, from the proximal extremity at point of contact with the dorsal cup to the distal tip, including in the region of the latter any structures that serve for anchorage. Cirri must be classed in this division.

The crown of crinoids comprises diverse sorts of ossicles, and all will agree that so far as possible each main category of these should be treated as a Division in the classification. Attention must be given to possibility or impossibility, as the case may be, of recognizing different categories among dissociated ossicles. We may begin by dividing the crown into two parts, the calyx and the free arms. The calyx, in turn, consists of the dorsal cup, lying below the base of the free arms, and the tegmen, which forms a roof over the body cavity. The term calyx is very commonly employed in a sense synonymous with dorsal cup where a tegmen composed of a solid pavement of calcareous plates is absent, but this is unimportant here. The dorsal cup is formed by two or more circlets of plates, with addition in some cases of a varying number of intercalated plates that do not belong in definite circlets. The plates of the bottommost circlet are designated as basals if they adjoin in alternating position the lowermost plates (radials) in the direct series of the rays or

arms, and crinoids in which basals compose the proximal circlet are called monocyclic. Plates of the proximal circlet are termed infrabasals if they occupy a radial position, being separated from the lowermost plates of the rays by a circlet of plates (basals) in interradial position; crinoids with this arrangement of plates at the base of the cup are called dicyclic. As already indicated, the lowermost plate in direct series with each ray is classed as a radial, and if other plates of the arm series are incorporated in the dorsal cup these are called brachials. Intercalated plates occurring between the rays above the circlet of basals are designated as interradials, except that those of the posterior interradius are separately treated under the name anals. Ossicles of the tegmen include orals, surrounding the mouth or occurring above it; ambulacrals, forming rows along the line of food grooves; interambulacrals, covering areas between the ambulacrals; and anal sac plates, including specialized slit- or pore-bearing plates and spines. The main branches of arms that rise from the upper border of the dorsal cup are formed of ossicles called brachials, and the relatively minute, generally very numerous branchlets (pinnules) occurring along the sides of the arms are composed of jointed segments called pinnulars.

If any or all of these several categories of ossicles in the crown of crinoids can be recognized in practically all cases when they are found dissociated, it is desirable to classify each such type as constituting a separate division. Unfortunately, difficulties are encountered on every hand, and although a majority of these could be solved readily by eliminating pre-Pennsylvanian crinoids from consideration, this is not a course to pursue. Taking account of all orders of crinoids, we note that in monocyclic forms the proximal circlet consists of plates called basals and that in dicyclic forms this circlet is composed of plates called infrabasals. Dissociated ossicles bearing part of a stem impression or an entire circlet of plates bearing a stem impression cannot be placed in a major assemblage called Division *Infrabasals* without ignoring the fact that basals of monocyclic crinoids are not infrabasals. Similarly, it would not do to designate this assemblage as Division *Basals*, for it would include infrabasals of dicyclic crinoids

and would exclude basals of dicyclic crinoids. The basis for recognition of plates belonging at the bottom of the calyx is presence of a stem impression, or in the case of stemless forms, presence of a centrodorsal plate or characters of shape such as are seen in the rounded base of *Agassizocrinus* (see fig. 8-*5*). A practical solution of the dilemma is to choose a name that denotes position of the ossicles at the base of a crinoid cup and that avoids commitment as to whether any particular stem-marked plates are basal or infrabasal. Such a term is apical, for the stem impression marks the morphologic apex of the dorsal cup. Definition of a division called *Apicals* serves the purpose of study of ossicles, notwithstanding the inclusion in one assemblage of basals belonging to three separate orders (Camerata Adunata, Inadunata) and infrabasals belonging to four orders (Camerata, Inadunata, Flexibilia, Articulata). Description and cataloguing of ossicles does not require distinction according to zoological orders and families.

Having disposed of plates belonging to the bottommost circlet of the crinoid cup, question comes next to the classification and designation of higher circlets. In monocyclic crinoids the plates adjoining those which we propose to call apicals are the radials; among adunates and inadunates of this type the radials bear facets at the distal border for articulation with the first segment of the free arms, but among camerates the radials have no such facets, being separated from the base of free arms by brachials that are incorporated in the dorsal cup. An interradial (anal) plate may be introduced between the posterior radials, touching the circlet of apicals. In dicyclic crinoids the plates occurring next above the apicals are basals, which in no case bear facets for articulation with arms. It is neither possible nor desirable to place all these plates that adjoin apicals in a single assemblage. Facet-bearing radials can be differentiated from radials without articular facets and from basals and anals, whereas plates of the dorsal cup and tegmen that have neither stem markings nor facets cannot be differentiated, considering all types of crinoids together. In the dorsal cup of camerate crinoids the brachial plates that bear articular facets for connection with the free

arms must be classified with facet-bearing radials. Thus, two divisions of plates above the apicals can be made, one characterized by presence of an articular facet for contact with a free arm and the other lacking this facet. Since the first of these includes both radials and brachials and excludes some radials (among camerates), this division cannot advisedly be called *Radials*, and because the presence of the articular facets is a distinguishing character, the name *Facetals* is proposed. The remaining ossicles have only their polygonal shape in common, and a suitable designation for the assemblage of these ossicles seems to be *Polygonals*. Certain subdivisions of polygonals can be recognized easily, as in the case of basal plates of Upper Carboniferous inadunate crinoids, but it seems necessary to define these as a minor rather than a major assemblage (see fig. 3).

A separate category may be erected for ossicles of the tegmen of some crinoids that can be distinguished definitely. These ossicles are the specialized plates of the anal sac in several inadunates and some camerates, identified by peculiarities of their form. Some are spines of various sorts, and others are bordered by strongly marked grooves. There may also be some orals and other tegminal plates that are distinguishable, and all of these are to be included in the Division *Tegminals*. A majority of the plates of crinoid tegmens, if considered at all, will have to be classified as polygonals because they lack indication of their structural position.

Segments of the free arms are characterized by the presence of articular facets for movement in relation to other plates below and above. There are two facets on ordinary brachials and three on axillary brachials, the segments that support two branches. All ossicles of these types are generally determinable as to nature, whether occurring singly or a number of them joined together. It is preferable not to erect a division of ossicles called brachials, however, because this name is applied also to plates of the arm series that are rigidly built into the dorsal cup of camerate crinoids. An alternative designation Division *Pinnates* is suggested. There is question whether characters of pinnules are sufficiently distinctive to make these worthy of much attention, but some of them can be separated

readily from others. They might be segregated as Division *Pinnulars*, but it seems preferable at present to include these with pinnates.

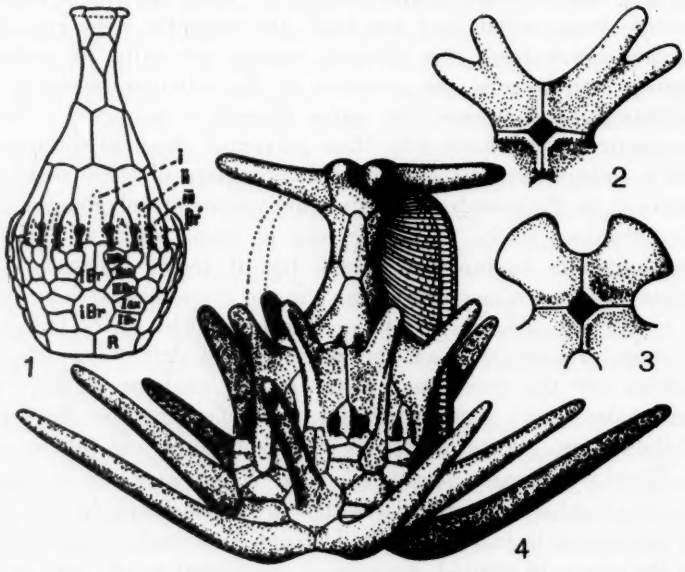


FIG. 3. DRAWINGS OF TWO TYPES OF SILURIAN CRINOIDS, TO ILLUSTRATE PROBLEMS IN IDENTIFICATION OF INDIVIDUAL OSSICLES OR SMALL FRAGMENTS OF THE CALICES IF FOUND DISSOCIATED

Without knowledge of the structural position and relation of plates to one another it would not be possible to distinguish individual plates as radials, brachials, interradials, or even plates of the tegmen instead of the dorsal cup. *1*, *Callicrinus costatus*, side view of calyx; *3*, plates at distal end of anal sac in this species, enlarged. *4*, *Callicrinus murchisonianus*, side view of calyx; *2*, plates at distal end of anal sac. (After Bather.)

Six main assemblages of crinoid ossicles have been suggested, The Divisions *Columnals*, *Apicals*, *Facetals*, *Polygonals*, *Tegminals*, and *Pinnates*. These are not of equal importance, and it is evident that each division is likely to contain ossicles having little stratigraphic value. On the other hand, each is likely to hold groups and sections that will prove to be definitely useful,

and this field of research is by no means limited to the kinds of ossicles found in known forms of whole crinoids. The primary aim in efforts to formulate a workable classification of ossicles, indeed, is a systematic disposition of fragmentary crinoid material representing unknown genera and species. How great may be the contribution to paleontologic and stratigraphic knowledge from work on crinoid parts is conjectural, because until now almost no attention has been paid to such material.

SYSTEMATIC DESCRIPTION OF CRINOID OSSICLES

Partly as demonstration of the manner of classification and nomenclature of crinoid ossicles that has been discussed in the preceding part of this paper, and partly as a laying of groundwork for intended descriptive paleontologic reports on Upper Carboniferous and Permian fossils of this type, attempt is made to define a number of major and minor assemblages of these fossils, with description of morphologic features of each. Although the designated assemblages of different rank are measurably arbitrary in some respects, knowingly ignoring lines of division that are deemed important in zoological classification, this appears to be necessary in dealing with dissociated ossicles. For example, columnals belonging to representatives of the Flexibilia and Camerata may here be associated with those of certain Inadunata. In spite of this, and in spite of a method of designation that expressly avoids application of rules of zoological nomenclature, it is thought desirable to follow the general form and methods of systematic paleontology. Thus, we may proceed.

Division CRINOSTYLI Moore (Columnals)

All ossicles of crinoids occurring below the dorsal cup are included here. Chief among these are segments of the stem or column, but we may place in this division, also, ossicles of cirri and structures of various sorts that serve as anchorage. Not all types of columnals, thus broadly defined, are likely to prove useful in stratigraphic studies, but many of them certainly have value. After brief consideration of general morphologic characters, indicating features that may be employed in classification,

a few of the subdivisions that seem appropriate are specified. The name of the division is derived from the Greek, *krinon*—lily (crinoid) and *stulos*—stem; other roots used in names for assemblages of columnals are *elleipsis*—ellipse, *kuklos*—circle, *ope*—hole, and *pentagonon*—pentagon.

Morphologic Characters.—Most crinoid columnals consist of discoid, keg-shaped, or platelike segments that are pierced centrally by a canal with axis normal to surfaces of articulation of the segments. Features that are useful in differentiation of subordinate major assemblages (main groups and groups), and individual kinds (sections) of these ossicles include chiefly,

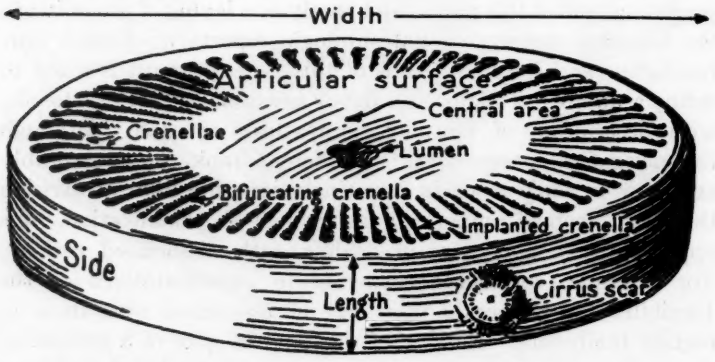


FIG. 4. OBLIQUE VIEW OF A COLUMNAL TO SHOW MORPHOLOGIC FEATURES

shape and general proportions of the segments, shape and relative size of the central canal or lumen, and markings on the articular surfaces. The configuration of the periphery, including ornamentation and facets for attachment of branches (cirri and branches of cirri), are other characters that call for notice in classification of some columnals (see Figure 4).

The shape of most crinoid stem is circular in cross-section, and this is also the shape of individual ossicles of such stems, viewed in a direction normal to the articular faces. There are also pentagonal, quadrangular, elliptical, crescentic, stellate, and other shapes among these ossicles. It is well known that

the shape of columnals may show variation in different parts of individual crinoid stalks, and too, that in many stems one type of ossicle, called nodal, adjoins more or less strongly dissimilar ones, classed as internodals. The latter are generally smaller then the former and may differ in shape. Cirri are attached to nodal segments, although the scar of attachment may extend to adjacent internodals. The number of internodal columnals between any two successive nodals is constant in at least a major part of the stem of some crinoids, but shows variation in others. The ossicles of cirri generally resemble those of the stalk to which they are joined, except for their smaller size and greater relative length. This is by no means a universal rule, for elliptical and crescentic stem segments typically bear cirri that are circular in cross-section. Ossicles of the cirri of modern crinoids may carry a spine on one side (dorsal), and may differ somewhat from base to tip of the cirrus, the distal segment being a termin a claw in many cases.

The width of a columnal is commonly considered to be the greatest distance across the segment, measured parallel to the plane of an articular face. In the case of elliptical or crescentic columnals, the smallest as well as the greatest diameters may be specified in description. The length of a columnal is measured parallel to the axis of the stem, and unless otherwise indicated, this refers to greatest length. It is observed that the articular faces of many crinoid columnals are concave, so that the distance from one to the other is smallest near the position of the axial canal; it seems best to designate such measurements within the borders as thickness rather than length. Actually, these two terms are essentially synonymous.

The proportion of width to length of different crinoid columnals varies greatly, although width generally is several times larger than length. In some columnals this relationship is reversed. As in the case of shape, referring to cross-section, the ratio of width to length may show considerable variation from one part of a single crinoid stem to another, and between adjoining nodal and internodal segments. Nevertheless, it is necessary to give attention to this character in classificatory study of columnals.

The central opening, which marks the position of the axial canal in crinoid columnals, is called the lumen. The outline (cross-section) of the lumen may be circular, pentagonal, petaloid with five points, a five-pointed star, elliptical, or of still other shapes. The size of the opening may be very small, both actually and relatively, or it may be large, with diameter more than one half of the width of the segment. Obviously, these features have importance in classifying stem ossicles.

Markings of the articular faces of columnals consist chiefly of the fine radiating ridges called crenellae. These may be long or short, relatively coarse or very fine, of equal size or unequal. The numbers of crenellae may increase toward the periphery of the articular face either by implantation of short crenellae between long ones, or by bifurcation of long crenellae. Some columnals carry a more or less strongly elevated line that crosses the central part of the articular face. This structure, called fulcral ridge, denotes special flexibility of movement between segments, and is seen mostly on elliptical columnals.

Various sorts of granules, tubercles, spines, ridges, keels, or flanges occur on the periphery, or non-articulating surface of columnals. In a majority of cases, however, this surface is smooth; in longitudinal profile it may be concave, plane, or gently to strongly convex. The nature of the ornamentation of columnals, or lack of decoration, is of value in separation of individual sections but not for definition of groups.

A feature that occurs commonly among columnals, as in brachials and some other ossicles, is a rigid type of suture between adjacent segments, which is known as syzygy. This differs from fusion (anchylosis) of the segments in that a definite line of division remains even though the joined ossicles are a functional unit. Syzygal sutures in crinoid columnals may be recognized in some cases by the nature of the two exposed articular surfaces of a united pair of ossicles (dyad), or of three joined ossicles (triad). The significance of such compound ossicles in classification remains to be determined.

Classificatory Problems.—The chief practical difficulties in devising a satisfactory subdivision of the many different types of

crinoid columnals lie in gradation of characters from one part of a single crinoid stalk to another, and in association together in a given fragment of stem of two or more entirely different sorts of ossicles. It is to be remembered, however, that recognition of individual genera and species of crinoids as defined in zoological classification is not the object of study in work on columnals. The aim is to find a rational basis for assignment of these ossicles to groups that can be delimited from one another with sufficient exactness for purposes of designation and description. If it happens that two or three or even more kinds of columnals actually belong to a single kind of whole crinoid, and if each of these kinds is observed and reported in dealing with an assemblage of ossicles from some horizon, the only effect is an added number of entries in the list of fossils over that which would be needed if the fact of common origin were known. This is not an impassable barrier to use of such ossicles in stratigraphic studies. It is also to be remembered that if classification of columnals according to certain characters results in associations of ossicles that are widely separated in zoologic classification of the whole crinoids to which they belong, this likewise is not a serious matter. We may compare our task in classifying crinoid columnals to that of arranging a miscellaneous assortment of nuts and bolts into groups having like characters, such as number and pitch of threads, without effort to determine the particular machines from which they might have been disassembled.

It appears necessary to establish separate categories for columnals of different shape, even though some of these may occur together in a single fragment of crinoid stem. There is seemingly no way to provide satisfactorily for classification both of single ossicles and of combined nodals, internodals, and perhaps cirri except to treat each kind of ossicle as a unit and to indicate combinations by compounding or bracketing together the designations for the types represented. For example, if columnals of circular outline are referred to an assemblage called *Cyclostyli*, and those of pentagonal shape are placed in another called *Pentagonostyli*, individual ossicles of these two types could be designated readily by these terms; if a portion of stem is

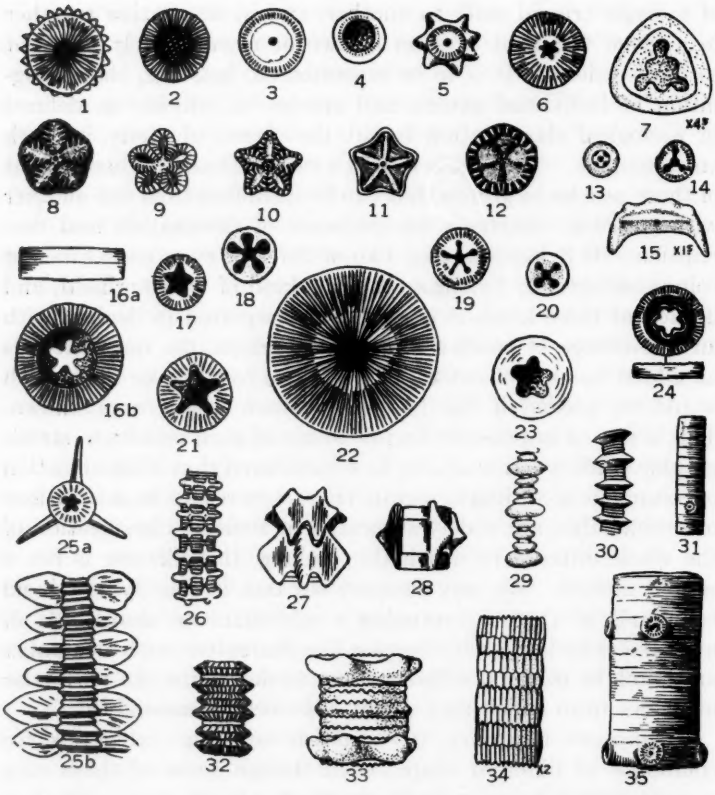


FIG. 5. DRAWINGS TO SHOW DIFFERENT TYPES OF COLUMNALS

Silurian, *27, 28*; Devonian, *7* (*Myrtillocrinus*), *13* (*Schultzicrinus*), *14* (*Schultzicrinus*), *15* (*Ammonicrinus*), *20* (*Myrtillocrinus*), *25* (*Gennaeocrinus*), *33* (*Melocrinus*), *34* (*Hallocrinus*); Mississippian, *2* (*?Periechocrinus*), *5* (*Teleiocrinus*), *6* (*Cactocrinus*), *22* (*?Actinocrinus*), *23* (*?Megistocrinus*), *26* (*Teleiocrinus*), *29* (*Cactocrinus*), *30* (*Eretmocrinus*), *32* (*Teleiocrinus*); Pennsylvanian, *16, 24, 31, 35*; Mesozoic-Recent, *8* (*Isocrinus*), *9* (*Pentacrinus*), *10* (*Isocrinus*), *11* (*Pentacrinus*), *12* (*Balanocrinus*); others unrecorded. (After Wachsmuth and Springer, *1–6 9, 17–19, 21–23, 26, 29, 30, 32*; after Goldring, *7, 13, 14, 20, 25, 33, 34*; after Bather, *8, 10–12*; after Girty, *16, 24, 31, 35*; after Springer, *15, 27, 28*.)

found having internodals classified as *Cyclostyli* with nodals classified as *Pentagonostyli*—and just such stems occur—the association of these two types in one fossil fragment might be recorded as *Cyclopentagonostyli*, or possibly by bracketing together the designations for the respective forms.

A few of the major subdivisions of columnals that appear to be useful for purposes of this study are given below. They are defined primarily on the basis of shape of the ossicles in cross-section. Subordinate assemblages within each of these can probably be differentiated chiefly on characters of the lumen, but in some cases other features may be more significant. (See Figure 5.)

Main Group CYCLOSTYLI Moore

Included under this designation are all crinoid columnals of circular or essentially circular outline in views normal to articular surfaces. Ossicles of cirri as well as those of the stalk itself may be embraced in the grouping.

Group CYCLOCYCLOPAE Moore

Cyclostyli with a circular lumen. Group-type (analogous to genotype, indicating the particular form of ossicle on which a group may be considered to be founded), *Cyclocyclopa acuticarinata* Moore.

CYCLOCYCLOPA ACUTICARINATA Moore

Plate I, figures 8a, b

Circular columnals with a relatively large circular lumen, (p. 186), mid-length of outer surface marked by a strong, sharp keel that girdles the ossicle, spaces between keel and borders of articular faces ornamented with granules arranged in rows normal to the keel. Crenellae very well defined but short, most of the space between lumen and edge of articular faces being covered with fine, irregularly disposed granules.

Two forms of ossicles may be distinguished, internodals and nodals, respectively. They are identical in appearance except for the slightly greater width and greater actual and relative

length of the nodals; some of the nodals also bear one or two marks of attachment of small round cirri, located uniformly on the same side of the keel in all such columnals, but whether this is distal or proximal is not known. The designation *acuticarinata* may be considered to apply to both types of ossicles, and if it is desired to specify one or the other, this can be done simply by written notation, as *Cyclocyclopa acuticarinata* (nodal). In a majority of cases both nodals and internodals will be found together forming intact pieces of the stem. It should be noted that all observed specimens show three internodals between each pair of successive nodals, the middle internodal being a little longer than the other two.

Measurements of columnals in four pieces of stem show extremely close correspondence in size and proportions of homologous elements. Width of articular face, 3.60 to 3.70 mm.; width of lumen, 1.10 to 1.25 mm.; greatest width of internodal, including keel, 3.90 to 4.20 mm.; same for nodal, 4.50 mm.; length of short internodals, 1.05 to 1.20 mm., of long internodal, 1.50 mm.; length of nodal, 1.65 to 1.80 mm. Number of crenellae on articular face, 36 to 39; length of crenellae, 0.30 to 0.40 mm.

Occurrence.—Stoner limestone member of Stanton formation (upper Stanton), Lansing group, Missouri series, Pennsylvanian (Upper Carboniferous); railroad cut one mile west of Wayside, Montgomery County, Kansas. E. L. Banion, collector.

Types.—Holotype, Kansas Univ. no. 0–59271; paratypes, nos. 0–59271a-c.

Group CYCLOPENTAGONOPAE Moore

Cyclostyli with a quinquepartite petaloid lumen, lobes of the lumen broadly rounded. Group-type, *Cyclopentagonopa granulosa* Moore.

CYCLOPENTAGONOPA GRANULOSA Moore

Plate I, figures 1a, b

Thin circular columnals with relatively large round-lobed pentapetaloid lumen. External surface smooth. Articular faces

divided sharply into a peripheral zone, about 2 mm. in width, bearing strong nearly even-sized crenellae, and a central slightly depressed area that bears irregularly disposed granules near the lumen but is smooth near the abrupt inner terminations of the crenellae. The number of crenellae ranges from about 45 to 65, counted at the inner margin of the crenellate zone, and about 65 to 75 at the periphery; increase in crenellae is chiefly by bifurcation.

Measurements of five specimens, some consisting of more than one columnal, show the following range: width of articular face (same as width of segment), 10.5 to 12.2 mm.; width of lumen, 1.8 to 2.0 mm.; length of columnal (no nodals recognized), 1.1 to 1.5 mm.; length of crenellae, 2.0 mm.

Occurrence.—Sam Creek limestone member of the Savanna formation, Des Moines series, Pennsylvanian (Upper Carboniferous); sec. 15, T. 10 N., R. 19 E., southwest of Porum, Oklahoma. C. L. Foster, collector.

Types.—Holotype, Kansas Univ. no. 0–45321; paratypes, nos. 0–45321a-d.

CYCLOPENTAGONOPA EXCENTRICA Moore

Plate I, figures 2a, b

Robust *Cyclopentagonopa* columnals in which the position of the lumen may be distinctly off center. External surface smooth. Size of segments belonging to a single stem very uniform, no nodals being recognized, although one specimen of stem contains 21 columnals. Articular faces divided sharply into two areas, consisting of a circular shallow bowl-shaped depression that is a little larger in diameter than the lumen, and surrounding this, a crenellate zone that may vary considerably in width because of the excentric location of the bowl and lumen. The sides of the shallow bowl are smooth. The crenellae are somewhat coarser toward the lumen than toward the periphery where there is notable increase in numbers through bifurcation and implantation. Counts of the number of crenellae at their inner extremities at the edge of the lumenal bowl show a range of 70

to 72 on four different faces. An average specimen shows 42 crenellae added by implantation and 20 by bifurcation, taking no account of the minute divisions appearing at the outermost margin.

The specimen that is classed as holotype consists of two segments, united apparently by syzygy so as to form a functional single element. This is indicated by the bowl-shaped depressions on the two exposed articular faces of the pair, for the depth of these hollows in each case equals about two-thirds of the length of the segment, and there is no space between the two segments along the walls of the lumen. No deformation of the columnals is observable. Whether or not segments of long stem fragments are arranged similarly in syzygal groups is not known, but this question might be answered by preparation of a longitudinal section through the lumen.

Measurements of two specimens, the inferred syzygal pair of segments and a piece of stem containing 21 columnals, show ranges as follows: width of articular face (same as width of segment), 22.0 to 23.5 mm.; width of lumen, 7.5 to 8.4 mm.; diameter of shallow depression forming crater around lumen, 10.2 to 10.5 mm.; length of columnal (no nodals recognized), 2.1 to 2.8 mm., average, 2.2 mm.; length of crenellae, 4.5 to 7.5 mm.

Occurrence.—Cap rock of Mineral coal, about 140 feet below top of Cherokee shale, Des Moines series, Pennsylvanian (Upper Carboniferous); sec. 25, T. 30 S., R. 24 E., two miles west of Pittsburg, Kans. G. E. Abernathy, collector.

Types.—Holotype, Kansas Univ. no. 0–60461; paratype, no. 0–60461a.

Main Group PENTAGONOSTYLI Moore

Crinoid columnals of subpentagonal, pentagonal, and pentastellate outline are included under this designation.

Group PENTAGONOCYCLOPAE Moore

Pentagonostyli with a circular lumen. Ossicles with a subcircular lumen, slightly modified perhaps in the direction of a pentagonal outline, cannot be differentiated with certainty from

those with perfectly circular shape and should be included in this division. Group-type, *Pentagonocyclopa dispar* Moore.

PENTAGONOCYCLOPA DISPAR Moore

Plate I, figures 4a, b, 5, 6a, b

Nodals and internodals rather strikingly dissimilar in appearance, though both are sharply pentagonal. Nodals moderately long, the length being nearly one half of the width, and distinctly wider than internodals. Each of the five sides parallel to the stem axis is almost wholly occupied by an elliptical scar of attachment of a cirrus, the scars on adjoining faces generally in contact along the sharp angles that define the pentagon; in some cases, however, the cirri bases are separated by a notch that indents the corners of the pentagon. A small round lumen at the center of cirrus scars is bordered on each side by a pair of diverging ridges that enclose a narrow depression, and the scars are surrounded by a narrow rim. They bear no crenellae. The articular faces show a sharply bounded zone of crenellae arranged in a pentagon, and inside of this a stellate depressed area surrounding the lumen. The crenellae are extremely short near the angles of the pentagon and increase in length toward the center of each side; they run normal to the sides of the pentagon and are very regular, showing increase neither by bifurcation nor implantation. Two typical nodals have uniformly 11 crenellae on a side of the pentagon in most cases, making about 55 all together on one face; a small example has 8 or 9 crenellae on a side, 42 in all. The lumen is round and small, like the central apertures in the scars of cirri. It is placed within a steep-walled, narrow-rimmed crater of decagonal (truncated pentagonal) form, marked with five slight inward bulges in the position of the angles of the pentagon of the nodal; the craters appear on each of the two articular faces of a nodal, one deeper than the other, and one showing five small swellings next to the lumen, alternating in position with the bulges of the wall previously mentioned. These are distinctive peculiarities, and combined with characters of the cirri markings, furnish easy basis for recognition.

The sides of internodal segments are nearly plane, the suture

lines between adjacent ossicles very slightly indented, the angles of the pentagon accentuated and sharpened by development of points or narrow crests. The crenellate zones of the articular faces touch the borders of the segments, unlike the nodals, in which the sides extend outward well beyond the crenellae. Characters of the lumen and associated crater appear comparable with those of nodals, although this is not certainly established.

Measurements of a typical large nodal and a small specimen are as follows: width of articular face, defined by outer edge of crenellate zone, 3.7 and 2.6 mm.; width of nodal, 5.5 and 4.3 mm.; width of lumenal crater, 1.5 and 1.0 mm.; width of lumen, 0.35 mm. and (?); length of nodal, 2.2 and 1.9 mm.; longest crenellae, 0.45 mm.; scars of cirri attachment, 2.1 mm. long, 3.0 mm. wide. Measurements of typical small internodals, width of articular face (same as width of segment), 3.0 mm.; length of segments, 0.42 mm. (average) to 0.84.

Occurrence.—Checkerboard? limestone, near base of Coffeyville shale, Ochelata group, Missouri series, Pennsylvanian (Upper Carboniferous); old brick pit in northwest part of Coffeyville, Kansas. R. C. Moore, collector. Typical specimens (nodal) of this form are contained in collections of Mrs. W. R. Marrs, Austin, Texas; locality and horizon not recorded, but probably lower Canyon beds northwest of Mineral Wells, Texas.

Types.—Holotype, Kansas Univ. no. 0–46071 (nodal); paratypes, no. 0–46071a (nodal), 0–46071b (stem fragment consisting of nodal and 14 internodals).

Main Group ELLIPSOSTYLI Moore

Crinoid columnals with elliptical articular faces. Nodals of circular, quadrangular, and other outlines are included if the marks of articulation which they bear are elliptical. Columnals generally marked by a strong fulcral ridge (see Figure 6).

Group ELLIPSELLIPSOPAE Moore

Elliptical columnals with an elliptical lumen. Group-type, *Ellipsellipsopa spicata* Moore.

ELLIPSELLIPSOPA SPICATA Moore

Plate I, figures 3a, b

These stem segments consist of subcircular spined discs that bear differently oriented elliptical facets on the two faces. The ossicles are small, measuring only 6 to 7 mm. in diameter, including spines that project 1 mm. or less; there are 10 or 11 of these spines, distributed a little unevenly around the disc.

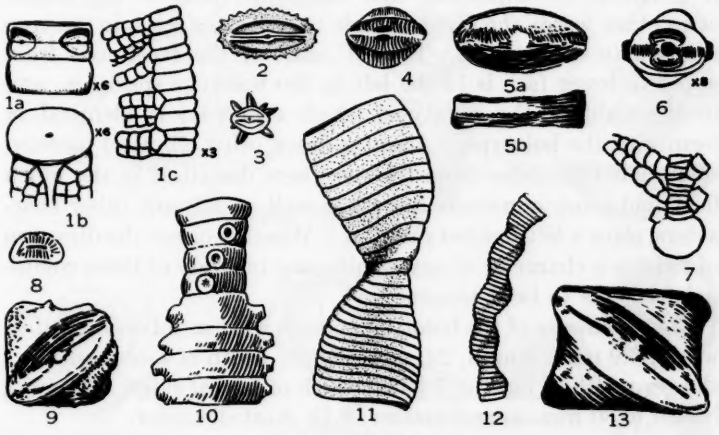


FIG. 6. ELLIPTICAL COLUMNALS

Silurian, *8* (*Myelodactylus*); Devonian, *7*, (*Myelodacylus*); Lower Carboniferous, *1* (*Camptocrinus*), *2* (*Eucladocrinus*), *3* (*Platycrinus*), *10* (*Platycrinus*), *11* (*Eucladocrinus*), *12* (*Platycrinus*); Upper Carboniferous, *5*, *9*, *13* (all *?Platycrinus*); Recent, *4*, *6* (both *Rhizocrinus*). (After Wachsmuth and Springer, *2–4*, *10–12*; after Springer, *1*, *7*, *8*; after Bather, *6*; after Tien, *5*, *9*, *13*.)

The elliptical facets are gently concave and are marked longitudinally by a very distinct but low fulcral ridge. The ridge is lowest near the center of the facet. This depressed part bears the small elliptical lumen. At the ends of the ellipse are three or four short crenellae that trend parallel to the ridge. The outer surface of the columnals is smooth except for the spines.

The long axes of the elliptical facets on the two sides are not parallel but diverge at an angle of about 80°. The direction

of rotation can be designated as dextral or sinistral if reckoned in terms of shift from proximal to distal parts of the stalk. This means from the top portion of the stem downward. It makes no difference whether the proximal and distal faces of a columnal showing twist of the axes of facets can be identified, for the direction of rotation is the same from upper to lower with either face held uppermost. The small angle between the axial lines is considered as representing the amount of rotation, although it is not at all impossible that the supplement of this angle, or in other words the greater angle between the axes, is the true rotation in some cases. The 80° shift of the facet axis from upper to lower face is to the left in the holotype specimen, and to the right in the paratype, which otherwise is identical in form with the holotype. About a dozen other elliptical facetted columnals that differ from the ones here described in the much finer and more numerous spines, as well as in some other characters, show a left-handed rotation. Whether or not the direction of twist is a character of any significance in study of these columnals remains to be determined.

Measurements of the holotype specimen are as follows: greatest width, 6.9 mm.; length, 2.0 mm.; longer width of facet, 5.4 mm.; shorter width of facet, 2.7 mm.; width of fulcral ridge, 0.75 mm.; lumen, 0.30 mm. long diameter, 0.15 short diameter.

Occurrence.—Checkerboard? limestone, near base of Coffeyville shale, Ochelata group, Missouri series, Pennsylvanian (Upper Carboniferous); old brick pit in northwest part of Coffeyville, Kans. R. C. Moore, collector.

Types.—Holotype, Kansas Univ. no. 0–46077; paratype, no. 0–46077a.

Division CRINOBASES Moore (Apicals)

Plates of the proximal circlet of crinoid cups, generally characterized by presence of a stem impression on part of the plate; includes basals of monocyclic crinoids and infrabasals of dicyclic crinoids. (See Figure 7.) The name of the division is derived from the Greek *krinon*—lily (crinoid) and *basis*—base; other roots used in names for assemblages of apicals include *ano*—

upward, *bathron*—base, *dis*—two, *hen*—one, *exo*—outward, *isos*—equal, *kato*—downward, *kuklos*—circle, *pentagonon*—pentagon, *pente*—five, *tetra*—four, *treis*—three, and *tupos*—impression.

Morphologic Characters.—Beginning at the proximal tip of an individual apical, or center of a circlet of apicals, attention may be directed to the notch or perforation that marks the point of emergence of the axial canal from the crinoid cup,

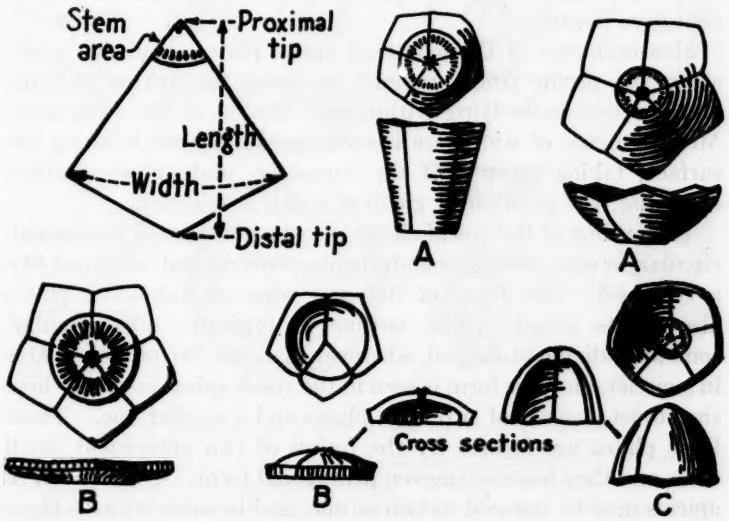


FIG. 7. DRAWINGS TO SHOW MORPHOLOGIC FEATURES OF APICALS

A, apicals flaring upward from stem area; *B*, apicals extending subhorizontally outward; *C*, apicals flaring downward.

corresponding to the lumen in columnals. As in the columnals, this opening may be variously shaped. On the inner side it may be bordered by a projecting rim or lip that in some cases projects upwards with vaselike form, or it may be adjoined by a rosette of prominences, commonly one on each plate.

On the outer side, the area of stem impression is sharply differentiated in most cases. It may be large or small, compared to the dimensions of the apical circlet, even extending beyond

the borders of this circlet. It is generally round, but may be pentagonal or elliptical. The plane of the stem impression may be entirely different from that of the distal portion of the apical plates. Primitively, the distal area of these plates slopes steeply upward, but it may extend almost directly outward in the approximate plane of the stem impression, or curve downward more or less strongly. The nature and amount of difference in position of the proximal and distal parts of apicals are almost always definitive features.

Measurements of the length of apical plates should be made along the profile from proximal to distal tip, taking account of respective parts lying within and outside of the stem area. Measurements of width are likewise preferably made along the surface, taking account of the curvature, and unless specified otherwise, the position of greatest width is selected.

The outline of the apical circlet may be pentagonal, hexagonal, circular, or exceptionally quadrangular, subtrigonal or shaped like a cogwheel. The form of different sorts of individual plates also varies greatly. The outline is typically quadrangular, somewhat diamond-shaped, wherever there are five of these plates in a circlet, and this form is seen in the small apical in cases where the circlet consists of two large plates and a smaller one. These large plates are formed by the fusion of two antecedent small ones, and they have an uneven pentagonal form. The number of apicals may be reduced to two or one, and in some crinoids there are four plates in this circlet.

The suture margins of these plates, like others of the dorsal cup, may be plane and devoid of markings, or they may be indented for reception of muscle and ligament fibres, and marked by denticles arranged in various patterns. Also, the thickness of apical plates varies considerably in different forms.

Classification of Apicals.—Study of many sorts of apicals and apical circlets indicates that differentiation of major groups can be based best on characters of the longitudinal profile of the plates, which indicates the structural attitude of these ossicles in the crinoid cup. Each major group thus defined may be subdivided on the basis of the angle between sides of the plates

diverging from the center of the stem impression, taking account also of the number of plates in the circlet. Supplemental features that are useful in classification include characters of the stem impression, axial canal opening, and in some cases relative thickness and suture markings. (See Figure 8.)

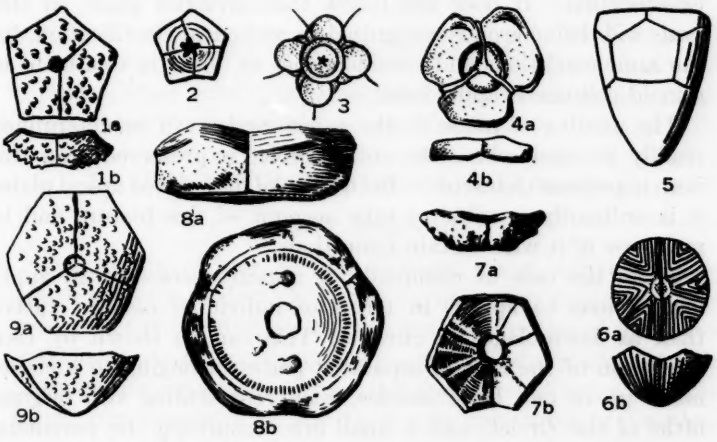


FIG. 8. SKETCHES OF A FEW TYPES OF APICAL CIRCLETS

Four apicals in circlet, *2* (*Melocrinus bainbridgensis*, Silurian), *3* (*Melocrinus tiffanyi*, Devonian); three apicals in circlet, *1* (*Platycrinus pocilliformis*, Mississippian), *4* (*Lobocrinus yandelli*, Mississippian), *7* and *8* (unknown genus; Permian), *9* (*Arthracantha ithacensis*, Devonian); two apicals in circlet, *6* (*Dichocrinus lineatus*, Mississippian); apical circlet consisting of a single fused piece, *5* (*Agassizocrinus conicus*, Mississippian). Fig. *5* shows a dicyclic crinoid; the apicals shown in other figures belong to monocyclic crinoids, with possible exception of *7* and *8*, which are unknown. (After Wachsmuth and Springer, *1–4*, *6*, *9*; after Springer, *5*; after Wanner, *7*, *8*).

The apical plates of crinoid cups that are convex at the base flare upward, their steepness of slope and longitudinal straightness or curvature defining conical or bowl-shaped forms of various sorts. Apical plates that extend directly outward from the stem impression, sloping appreciably neither upward nor downward, are seen at the base of flatbottomed cups having the

form of a truncated cone, bowl or globe, and they may also constitute the central part of a basal concavity of a crinoid cup. Downflaring apicals clearly denote a cup that is concave at the base. These characters of form distinguish various genera and species of crinoids and it may thus be presumed that the structural attitude of apical plates is a reliable and useful character for classification. It does not follow that divisions made on this basis will define groups recognized in zoological classification, for the same conditions and considerations as noted in treatment of crinoid columnals apply here.

The number of plates in the apical circlet can be determined readily in cases where the entire circlet is preserved, and this is an important character. In the case of dissociated apical plates it is ordinarily possible to take account of this feature and to make use of it with certain limitations.

As in the case of columnals, it appears necessary to apply designations to apicals in terms of individual ossicles, rather than as assemblages in circlets. This can be shown by consideration of the case of separated plates belonging to a circlet made up of two large ossicles, each representing two original fifths of the circlet, and a small one comprising the remaining one-fifth. It is evident that the last indicated plate, if found alone, would not be distinguishable from an apical of the type in which five similar plates make up the apical circlet, or if separated from the double-sized apicals would likewise not be determinable as part of a three-apical circlet unless distinguished by some peculiarities of markings. Accordingly, this small plate of the circlet with three apicals would have to be placed in the group to which plates of five-apical circlets are referred. Such disposition may be only a temporary expedient, however, for if evidence of the true nature of the small plate as part of a three-apical circlet is found, transfer could readily be made to the proper group. In the case of apicals described from complete circlets this may be recorded, if desired, by written notation in parentheses, as *Pentanobasis rotunda* (circlet).

A few of the groups of apicals are defined in the following paragraphs in order to show method of designation and description.

Subdivision ANOBASES Moore

Apical plates with distal part flaring upward from the stem impression.

Main Group ANOCYCLOTYPI Moore

Upward flaring apicals marked by a circular stem impression.

Group PENTANOBASES Moore

Anocyclotypi with five subequal plates in an entire circlet. Group-type *Pentanobasis regularis* Moore.

PENTANOBASIS REGULARIS Moore

Plate I, figures 10a-c

Description of this section is based on a complete circlet which shows a moderately broad circular stem impression comprising about one-fifth of the proximal extremities of the plates, and distal parts comprising a cone with height about one-third of the maximum width. The plates and the circlet as a whole are large, measurements of the type specimen showing length of each plate 12.5 mm., width 11.8 mm., greatest width of cone, 21.5 mm., height of cone, 6.5 mm. In longitudinal profile the slope of the distal part of the plates makes an angle of 32 degrees with the plane of the stem impression, or rather the rim of this impression, the central part of the stem area being gently concave. The border of the stem impression is separated by a groove from a sharp rim that surrounds the impression. There are 10 or 11 crenellae in the part of the stem impression borne by each plate and 52 around the periphery of the entire impression; the crenellae are approximately uniform in size and distinct in their outer portion, but fainter toward the center. The opening for the axial canal is nearly circular in outline, showing five faintly marked rounded lobes; the diameter of the slightly pentalobate opening is 2.0 mm. Internally, the axial canal opening is bordered by an elevated rim which has a strongly stelliform outline. The lobes of the opening and points of the rim on the

interior are directed toward the middle of each apical, which, assuming application of the "law" of Wachsmuth and Springer as to position of radial nerve grooves, indicates that the plates of this circlet are infrabasals of a dicyclic crinoid. The outer surface of the plates is smooth and unornamented. Sutures between them are faintly impressed. Characters of the suture faces can be seen only on the distal edges. In this region the plates have a thickness of 1.0 mm. The distal borders of the apicals are slightly crenulated, about 7 faint elevations and 7 depressions occurring on each of the two distal margins of one apical plate. A row of fine ligament denticles, with teeth trending roughly normal to the outer face of the plates, occurs on the distal suture faces, close to the crenulations mentioned and following their curvature. Except for the fine denticles the surface of the suture faces is smooth. The thickness of the plates at the distal margin is 1.0 mm.

This apical circlet consists of infrabasal plates that probably represent an undescribed species of *Ulocrinus*.

Occurrence.—Shale in the Stanton limestone, Ochelata group, Missouri series, Pennsylvanian (Upper Carboniferous); The Mound, at northwest edge of Bartlesville, Oklahoma. Collected by Paul McGuire.

Types.—Holotype, Kansas Univ. no. 0–45511.

Group TETRANOBASES Moore

Anocyclotypi with four plates of approximately equal width in the circlet, one being truncated distally. Group-type, *Tetranobasis nobilissima* (Hall).

TETRANOBASIS NOBILISSIMA (Hall), new comb.

The proximal circlet of the crinoid *Melocrinus nobilissimus* (Hall) is designated under this name as typical example of apicals that flare upward from a round stem impression, four nearly equal plates occurring in the circlet.

Occurrence.—Coeymans limestone, Lower Devonian; Litchfield, N. Y.

Type.—Hall's type of the whole crinoid, American Mus. Nat. History no. 2297/1, may be taken as showing the type example of this form of apicals.

Group TRIANOBASES Moore

Upflaring apicals primarily distinguished by width subtending two-fifths of the entire circlet; this is intended to define plates of an apical circlet consisting of two large plates and one small one, rarely, of one large plate and three small ones. Stem impression round. Group-type, *Trianobasis bridwelli* Moore.

TRIANOBASIS BRIDWELLI Moore

Plate II, figures 2a, b

A number of complete apical circlets in my collection, some with an attached portion of the stem, consist of three nearly vertical plates, two large and one small. Each of the two larger plates takes up about two-fifths of the circlet. The proximal extremities of the plates are occupied by the round stem impression, which is gently concave. In the form here described, the stem area is marked by about 45 slender crenellae that reach about halfway from the periphery to the lumen, becoming fainter inward. A nearly round, pentalobate lumen occurs at the center of the shallow concavity of the stem impression. A sharp, nearly right angled inflection separates this area from the remainder of the plates which comprises about four-fifths of their total length. The angle between the plane of the rim of the stem impression and the steeply upflaring sides of the circlet is 81°. The width of the circlet at the top, or distal margin, is only about 1.5 times as great as the diameter of the stem impression, and this measurement almost exactly equals the height of the circlet. The distal margins of the plates form nearly a straight line. The plates are thin, about 0.3 mm., and the suture faces are without observed markings. The outer surface is smooth; sutures between plates are not impressed but their position is readily determined.

Measurements of the holotype specimen are as follows: height of apical circlet, 6.0 mm.; greatest width of circlet, 6.3 mm.;

width of stem impression, 4.0 mm.; length of distal part of apical plate, beyond stem impression, 6.2 mm.; greatest width of large apical, 8.0 mm.; of small apical, 4.1 mm.; diameter of lumen, 1.2 mm.

These apical circlets are composed of infrabasal plates belonging to an undescribed genus.

Occurrence.—Toronto limestone member of Oread limestone, Shawnee group, Virgil series, Pennsylvanian (Upper Carboniferous); quarry in sec. 27, T. 13 S., R. 19 E., southwest of Lawrence, Kans. Arthur Bridwell, collector.

Types.—Holotype, Kansas Univ. no. 0–45701, paratype, 0–45701a.

Group ISOTRIANOBASES Moore

Anocyclotypi with three approximately equal-sized plates to the circlet. Group-type, *Isotrianobasis urna* Moore.

ISOTRIANOBASIS URNA Moore

Plate I, figures 11a-c

A complete circlet furnishes basis for differentiation of this form. It has the shape of a low urn with a well marked constriction just above midheight. The stem impression, 6.8 mm. in diameter in the holotype specimen, is gently concave and is bordered by a rather sharply raised rim. The lumen, which is 1.0 mm. in diameter, is round, but on the inner side the opening appears distinctly pentalobate. About 60 fine crenellae may be counted around the periphery of the impression; these become very faint toward the lumen. From the top of the rim surrounding the stem impression the surface of the plates slopes evenly upward and outward to the bulge that girdles the circlet just below midheight; above the bulge is an upward and inward slope, and near the distal margin of the plates the attitude of the surface is nearly vertical. The height of the circlet is slightly more than one-half of the width, height of the holotype specimen being 7.5 mm. and the greatest width, 13.2 mm. The distal margin of each apical shows a truncated, slightly scalloped middle section and

slopes from the margins of this scallop to the upper angles of the plate. The entire circlet thus shows six facets for union with plates of the next higher circlet, indicating that these apicals belong to a monocyclic crinoid and that one of the plates of the following circlet is an anal, the others being radials. The width of the suture faces, representing the thickness of the plates at their distal border, is about 2.2 mm. The interior of the circlet slopes evenly from the margin of the suture faces to the axial canal opening, which shows that the external bulge near the mid-height is entirely due to thickening of the plates. On the inner side the three sutures between the apicals are marked by a deep narrow furrow, whereas these lines of division are barely preceptible on the outer side. The surface of the apicals is perfectly smooth.

This apical circlet corresponds in characters most closely to that of *Lobocrinus pyriformis* (Shumard) from the upper Burlington limestone, and probably belongs to this species.

Occurrence.—Burlington limestone, Osage group, Mississippian (Lower Carboniferous); Springfield, Mo. Bob Stevens, collector.

Type.—Holotype, Kansas Univ. no. 0–60471.

Group DIANOBASES Moore

Apicals that flare upward, each subtending half of the circle, making two plates to the circlet; stem impression round. Group-type, *Dianobasis lineata* (Meek and Worthen).

DIANOBASIS LINEATA (Meek and Worthen), new comb.

The basal circlet of *Dichocrinus lineatus* Meek and Worthen is designated as typical example of the group here treated, and although the names given are technically *nomina nuda*, like all others in the classification for ossicles, use of Meek and Worthen's species name and indication of their original description appears permissible. At any rate, neither infringement nor misunderstanding should be involved. Description of the apical circlet is adequately given in earlier publications (Meek and Worthen, Illinois Geol. Survey, vol. 5, p. 440, pl. 3, fig. 1; Wachsmuth and

Springer, North American Crinoidea Camerata, p. 761, pl. 76, figs. 4a-c).

Occurrence.—Burlington limestone, Osage group, Mississippian (Lower Carboniferous); Burlington, Iowa.

Type.—The basal circlet of the holotype specimen of *Dichocrinus lineatus* may be taken as type of this section.

GROUP HENANOBASES Moore

Upflaring circlet of apicals more or less completely fused into a single solid piece, with round stem impression or lacking trace of stem impression. Group-type *Henanobasis coffeyvillensis* Moore.

HENANOBASIS COFFEYVILLENSIS Moore

Plate II, figures 3a-c; plate III, figure 11

Apicals fused to form a solid calcareous piece shaped like bullet; sides in distal half vertical and parallel, asymmetrically rounded in the proximal region. A small round stem impression, 0.8 mm. in diameter, is clearly marked in an excentric position at the base of the ossicle. It is distinctly concave and contains a very small round opening at its center. The plane of the impression is obliquely inclined to the axis of the fused apicals. The distal margin bears five shallow scallops which mark the position of attachment of plates belonging to the next series. One of these scallops is divided into two halves by a median ridge directed radially, and another is similarly indented by two cross ridges so as to form three small depressions. A relatively deep central cavity lies within the faceted border. Crystallographic orientation of the five fused elements differs in each and, although no sutures between them can be seen, examination of light reflections from cleavage surfaces permits determination of the boundaries between individual segments. These lines tend to run vertically from the border of the stem impression to the middle of a scallop at the distal end of the mass, but there is a curious departure from this plan in the case of one of the boundaries. This one swings toward the right so as to meet another boundary at the top, thus indicating that about two-fifths of the distal

border is formed by one element, whereas its neighbor on the right ends in a point at the center of one of the scallops.

Measurements of the type specimen are as follows: height of apical piece, 10.8 mm.; greatest width, 8.1 mm.; depth of central concavity, 3.0 mm.; width of facet border, 2.2 mm. This section is distinguished by its shape and moderately small size. Probably it represents the infrabasal cone of a species of agassizocrinid.

Occurrence.—Checkerboard? limestone, near base of Coffeyville shale, Ochelata group, Missouri series, Pennsylvania (Upper Carboniferous); old brick pit in northwest part of Coffeyville, Kans. Arden Kemler, collector.

Type.—Holotype, Kansas Univ. no. 0–46072.

Main Group ANOPENTAGONOTYPI Moore

Upward flaring apicals with a pentagonal stem impression.

Group PENTANOBATHRA Moore

Upflaring apicals, each subtending one-fifth of the circumference of this circlet, and bearing part of a pentagonal stem impression. Group-type *Pentanobathrum rosei* (Moore and Plummer).

PENTANOBATHRUM ROSEI (Moore and Plummer), new comb.

Various crinoids such as *Hydriocrinus? rosei* Moore and Plummer and *Hydriocrinus pusillus* Trautschold have a proximal circlet corresponding to that defined in the group *Pentanobathra*. The infrabasal circlet of *H.? rosei* is here designated as type example of this group of apicals, using the same designation, *rosei*, as given to the whole crinoid. It is reasonably certain that isolated apicals or complete circlets of this general form but differing from this one, will be found.

Occurrence.—Brentwood limestone?, Morrow series, Pennsylvanian (Upper Carboniferous); east bluff of Grand River, near Keough quarry, about two miles north of Fort Gibson, Oklahoma. Ralph Rose, collector.

Type.—Same as holotype of *Hydriocrinus? rosei* Moore and Plummer, Kansas Univ. no. 45197.

Subdivision EXOBASES Moore

Apical plates in which the distal portion extends directly outward without well defined upward or downward slope from the stem impression.

Main Group EXOCYCLOTYPI Moore

Outward flaring subhorizontal apicals with a circular stem impression.

Group PENTEXOBASES Moore

Exocyclotypi with five plates to the circlet. This corresponds in characters to the proximal circlet commonly seen in such genera as *Dicromyocrinus, Eupachycrinus* and *Ethelocrinus.* Group-type *Pentexobasis glypta* Moore.

PENTEXOBASIS GLYPTA Moore

Plate I, figures 9 a-c

Description of this section is based on well preserved examples of complete apical circlets, which as a whole have a flat pentagonal form. There are five equal plates, each a little less wide than long, the proximal portions occupied by a round stem impression that is slightly flattened on five sides. Each plate bears 9 or 10 even crenellae that have a beadlike outer elevation, which is distinct from the inner part reaching about halfway to the axial canal opening. This latter is small and quinquelobate-rounded, the lobes being directed toward the center line of each apical. Position of the rays of the opening, stratigraphic occurrence and resemblance to the proximal circlet of species of *Ethelocrinus* indicates that these circlets are infrabasals, belonging to *Ethelocrinus, Dicromyocrinus* or similar genus. The exterior of the distal portion of each plate is ornamented by three strong radially placed ridges, the two outer ones touching the rim that surrounds the stem impression and the middle one beginning a short distance

outward from the rim. This ornamentation, together with other features described, serve readily for identification. The two distal margins of each apical are marked by four or five crenulations and on the suture face beneath these are delicate ligament teeth forming a somewhat labyrinthine pattern in groups that correspond to the crenulations. Otherwise the suture faces are plane and smooth. On the inside of the circlet the sutures are very clearly marked, becoming somewhat impressed near the axial canal opening; the proximal tips of the plates appear slightly raised.

Measurements of the type example are as follows: greatest width of circlet, 16.5 mm.; diameter of stem impression, 6.0 mm.; length of apical plate, 10.0 mm.; width, 8.0 mm.

Occurrence.—Cap rock of Mineral coal, about 140 feet below top of Cherokee shale, Des Moines series, Pennsylvanian (Upper Carboniferous); sec. 25, T. 30 S., R. 24 E., about two miles west of Pittsburg, Kans. A. M. Brooks, collector.

Types.—Holotype, Kansas Univ. no. 0–60468; paratypes, nos. 0–60468a-d.

PENTEXOBASIS PLANA Moore

Plate IV, figures 1 a-c

Circlet similar to that last described, but surface of plates smooth except for very faint irregular depressions; the outer surface of each plate is gently convex, the sutures being slightly impressed. The stem impression is round, but the crenellae are arranged to emphasize a pentameral grouping; in fact, there is a well-marked pentagonal furrow with sides parallel to the transverse axes of the plates just inside the edge of the stem impression, and the even lines of inward termination of the crenellae also define a pentagon. There are 8 crenellae on the proximal part of each apical, making 40 in the whole stem impression. The axial canal opening is pentastellate, the points of the star being directed toward the center lines of the apicals; on the inner side there is a star-shaped elevated rim around this opening. The suture faces are plane except for bundles of irregular fine denticles near the outer margin.

Measurements of the holotype specimen are as follows: greatest width of circlet, 15.0 mm.; length of apical, 8.5 mm.; width of apical, 6.7 mm.; diameter of stem impression, 4.8 mm.; diameter of lumen, 1.2 mm.; thickness of plate at distal suture face, 1.0 mm.

These apicals probably belong to a species of *Ethelocrinus*, or perhaps *Dicromyocrinus*. Because they are associated with abundant plates classed as *Macrocrinarthrum corrugatum* and *Schedaglaopolygonum corrugatum*, it is possible that they represent the same species as these, but this is not certain.

Occurrence.—Checkerboard? limestone, near base of Coffeyville shale, Ochelata group, Missouri series, Pennsylvanian (Upper Carboniferous); old brick pit in northwest part of Coffeyville, Kans. R. C. Moore, collector.

Types.—Holotype, Kansas Univ. no. 0–46073; paratype, no. 0–46073a.

Group TRIEXOBASES Moore

Apicals without distinct upward or downward flare, bearing round stem impression, and including primarily plates with width equal to two-fifths of the entire circlet. This refers to circlets having three plates, two large ones and a small one, or possibly one large plate and three small ones. Group-type, *Triexobasis banioni* Moore.

TRIEXOBASIS BANIONI Moore

Plate II, figures 1a, b

An entire circlet of apicals to which two plates of the second series are attached, is selected for definition of this section. There are two large apicals with pentagonal outline, each comprising about two-fifths of the circlet, and a third smaller one that is quadrangular. The angles between the suture lines are respectively 140°, 120°, and 100°. The stem impression is relatively large, circular, and rather strongly concave. It is devoid of markings except fine irregular ridges, like ligament denticles, near the lumen. At its edge is a wall, a little less than a milli-

meter in height, that overhangs slightly inward. The distal part of the plates, beyond the area of the stem impression, is very short, forming little more than a border for the concave stem area. The surrace is smooth. On the inside of the circlet, the surface slopes rather evenly upward from the distal edges of the plates to the center, where a three-cornered, tryllium-like depression, bordered by a narrow rim, marks the opening of the axial canal. The points of the triangular center are directed toward the middle portions of the three plates. The sutures between the plates are strongly depressed on the inner side of the circlet.

Measurements of the circlet are as follows: greatest width, 10.2 mm.; diameter of stem impression, 8.3 mm.; height of concavity of stem impression, 2.5 mm.; length of apical, 5.5 mm.; greatest width of large apical, 8.3 mm.; long side of triangular crater around lumen on inside of circlet, 2.0 mm.

The type of circlet here described is that typically seen in the genus *Cibolocrinus*, and occurrence of associated plates bearing the same peculiarities of ornamentation as appear on basals attached to the apical circlet establish the conclusion that these ossicles belong to an undescribed species of the genus mentioned.

Occurrence.—Brownville limestone, Wabaunsee group, Virgil series, Pennsylvanian (Upper Carboniferous); railroad cut at Keefe, seven miles southwest of Strohm, Osage County, Oklahoma. E. L. Banion, collector.

Type.—Holotype, Kansas Univ. no. 0–59971.

Main Group EXOPENTAGONOTYPI Moore

Apicals that extend outward from the stem impression with little or no upward or downward slope, stem impression distinctly pentagonal or pentastellate in outline.

Group PENTEXOBATHRA Moore

Outward flaring subhorizontal apicals with a pentagonal stem impression and five plates to the circlet. Group-type, *Pentexobathrum magnificum* (Miller and Gurley).

PENTEXOBATHRUM MAGNIFICUM (Miller and Gurley), new comb.

The infrabasal circlet of *Aesiocrinus magnificus* Miller and Gurley is designated as typical example of the group of *Pentexobathra*. The circlet has the form of a regular pentagon that is small and flat. The points of the pentastellate stem are located on the suture lines between the five plates of the circlet.

Occurrence.—Lane shale, Kansas City group, Missouri series, Pennsylvanian (Upper Carboniferous); Kansas City, Mo.

Type.—The holotype specimen of *A. magnificus* in the Walker Museum collection, University of Chicago, may be considered as including the type of this group of apicals.

Subdivision CATOBASES Moore

Apical plates that slope more or less distinctly downward from the area of the stem impression.

Main Group CATOCYCLOTYPI Moore

Downward flaring apicals that bear marks of a circular stem impression.

Group PENTECATOBASES Moore

Catocyclotypi with five subequal plates in the circlet. Group-type, *Pentecatobasis excavata* Moore.

PENTECATOBASIS EXCAVATA Moore

Plate I, figure 12

Apical circlets of the type defined as *Pentecatobasis* occur in *Delocrinus*, one of the most common Upper Carboniferous crinoid genera, and in numerous other forms from this and other horizons. An example is described and figured here.

The circlet has the shape of a small rounded dome, the inner surface of the plates forming the outside of the dome and the outer surface of the plates being on the inside of the dome. The stem impression occurs on the under side, beneath the crest of the

dome. The round area of the impression includes not only the nearly flat space, 3.0 mm. in diameter, at the top of the concavity but an adjoining zone that extends about 1.5 mm. downward on the sloping sides; this is indicated by the disposition of the crenellae, which radiate from the vicinity of the lumen to a circle located on the inner side of the dome distinctly below its roof. Each apical plate bears 6 crenellae, making 30 in the entire area of the impression. The axial canal opening is distinctly but not strongly pentalobate, viewed from the side of the stem impression, but on the opposite side it is markedly stelliform. The proximal half of the downflaring portion of each apical has practically a vertical position on the inside of the dome, the distal part flaring outward at a distinct angle. The surface is smooth. The inner surface of the plates (on the outer side of the dome) slopes in a fairly regular curve, the lower part being longitudinally fluted; there are three rounded ridges that terminate at the distal border of each apical. The suture faces, which can be seen only at the distal edges of the plates, are peculiar in showing ten deep pear-shaped pits, two on each apical, arranged so that the narrow part of the pit is pointed toward the distal tip of the plate on which it is located. The borders of the pits, which form the contact surface for the adjoining circlet of plates, are marked by minute denticles. The distal extremities of the five plates, taken together, form a regular pentagon with slightly scalloped outline.

Measurements of the holotype specimen are as follows: height of circlet, 4.5 mm.; greatest width of circlet, 7.4 mm.; height of basal concavity, 3.4 mm.; length of apical, including stem area, 6.0 mm.; width of apical, 3.5 mm.; greatest thickness of plates at distal margin, 1.6 mm.; pit on suture face, 1.5 mm. long and 0.6 mm. wide.

The apical ossicles here described probably belong to a species of *Delocrinus*. The distinctive features of *P. excavata* are the pits on the distal suture faces, the extension of crenellae of the stem impression on to the downsloping sides, and the fluting of the distal part of the interior surface of the plates.

Occurrence.—Havensville shale member, Wreford limestone,

Council Grove group, Big Blue series, Lower Permian; SW¼ SE¼ sec. 33, T. 18 S., R. 6 E., about five miles northwest of Elmdale, Kans. M. K. Elias, collector.

Type.—Holotype, Kansas Univ. no. 0–33061.

Division CRINARTHRA Moore (Facetals)

Ossicles that bear an articular facet for union with the lowermost segment of a free-moving arm are termed facetals. They include radial plates of adunates, inadunates, articulates, and some flexible crinoids, and brachial plates of camerates and some flexibles. Distinction between ossicles classed as facetals and those called pinnates rests primarily on whether only one articular facet or more than one is present on the ossicle; pinnates have two or more such facets. The name of the division is derived from the Greek *krinon*—lily (crinoid) and *arthron*—joint; other roots used in names for assemblages of facetals are *bounos*—crest, *eggonios*—angular, *leios*—smooth, *lophos*—ridge, *makros*—long, *platus*—wide, and *stenos*—narrow.

Morphologic Character.—The shape and general appearance of facetals vary widely. Length may be much greater than width, or vice versa, and commonly these dimensions are not very different from one another. The lower (proximal) and lateral margins are suture faces that join with plates of the dorsal cup. Generally these faces lie in planes that are approximately normal to the outer surface of the plate, but they may be inclined, and in some cases they bear pits or shallow depressions for reception of muscle and ligament fibres. The distinctive part of facetal plates is the facet at the distal edge. This furnishes characters that are useful in classification, and morphologic description is focussed chiefly on the nature of different sorts of facets. (See Figure 9.)

A broad two-fold grouping may be made among facets that appear on ossicles of this division. One group includes relatively plane facets that lack a fulcral ridge or other specialized features denoting well developed muscular articulation. The other group possesses these marks. The outline of the facets in the first group tends to be roughly circular, and the distance across the

facet about as great in one direction as in another. The inner or distal edge of the facet is commonly indented in a manner corresponding to the ambulacral groove on the ventral side of arm segments above the facetals. In addition, there may be a

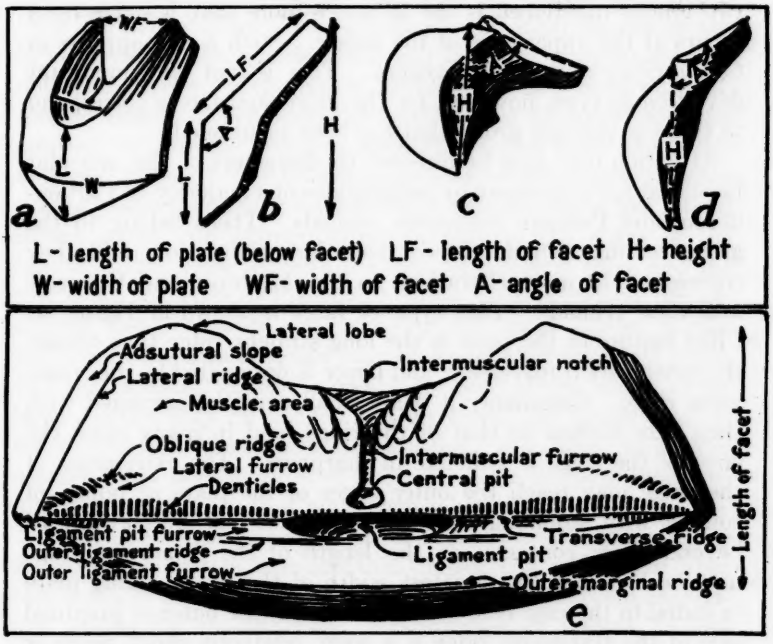


FIG. 9. DRAWINGS TO SHOW MORPHOLOGIC CHARACTERS OF FACETALS

a, Oblique view of a facetal (radial plate) with facet distinctly narrower than greatest width of ossicle; *b*, same in profile view. *c*, *d*, Profiles of two other radial plates, showing height and angle of facet. *e*, Diagram showing features of the articular facet observed on radial plates of some late Paleozoic inadunate crinoids.

perforation through the middle part of the plate for passage of the dorsal canal. The face of the articular area may bear denticles such as are characteristically associated with the ligament structures between plates of the crinoid skeleton. The outline of the facet in the second group is also rounded in the

more primitive forms, but it tends to show a distinctly angular shape that is associated mainly with increased width of the facet and stronger development of ridges and grooves that aid in muscular articulation.

A type of facetal that is not placed readily in either of the two groups mentioned is one in which more than a single facet occurs at the upper edge of the ossicle. Such a case appears in *Catillocrinus* and similar genera. This is not an important deviation in type, however, for the individual facets correspond to those of the first group that has been mentioned.

Attention may now be directed to characters of the articular facet that are well shown by radial plates of a majority of Carboniferous and Permian inadunate crinoids. These belong to the group having well developed muscular articulation, and they correspond in most characters to the Mesozoic and Cenozoic articulate crinoids. This type of facet is shown in Figure 9*e*. Chief feature of the facet is the long straight ridge that crosses the outer part transversely, and hence is designated as the transverse ridge. Commonly it bears small denticles arranged with their axes normal to that of the ridge, and in many cases the crest of the ridge is knifelike in sharpness. The extremities of the ridge may reach the outer edges of the plate at points of contact with adjoining plates, or at points that are set outward beyond these contacts; or the length of the transverse ridge may be less than the greatest width of the facet-bearing plate (a radial in the case here considered). On the outer or proximal side of the transverse ridge is a wide, relatively short, more or less depressed space designated as the outer ligament area; it may be bounded on the proximal side by a distinct ridge, the outer marginal ridge, and within it there may be a median ridge. Next to the transverse ridge in the central part of the outer ligament area is a deep slitlike furrow, the ligament pit. Fine denticles are present in many cases in parts of the outer ligament area or over all of it. The part of the facet lying on the inner or distal side of the transverse ridge is termed the inner ligament area. Near the lateral extremities of the ridge and parallel or slightly oblique to it on the inner side are more or less deeply

marked furrows, the lateral furrows, and on the inner side of these in turn are elevations, generally denticulate, that trend obliquely, the oblique ridges. Close to the transverse ridge at the center on its inner side is a rounded or subtriangular depression called the central pit, and from this a narrow groove is very commonly observed to extend to the inner border of the facet, dividing the muscle areas and therefore termed the intermuscular furrow. The muscle areas are broad, somewhat ill-defined spaces of subtriangular outline that in some cases are marked by furrows trending roughly parallel with the intermuscular furrow. The lateral boundaries of the muscle area are generally sharp and may be marked as definite ridges, the lateral ridges, which run approximately parallel to the edges of the facetal. The space between the crest of a lateral ridge and the suture at the edge of the facet-bearing plate is termed the adsutural slope. Inward extensions of the facet border in the position of the lateral ridges may be designated as lateral lobes, and the indentation that is commonly seen at the center of the inner border may be termed the intermuscular notch. All of these structural features show variation, and study of facetal ossicles must take account of them in order to distinguish the many different kinds that are recognizable.

Study of the characters of crinoid cups, especially those of late Paleozoic inadunates, indicates that the attitude, width, and other characters of the radial facets are reliable and important foundation stones for classification. Examination of facetal ossicles readily shows whether the width of the facet equals the greatest width of the plate or is less than this, but it is not possible to determine with certainty what was the original attitude of the facet, whether it sloped strongly or moderately outward, was horizontal, or sloped inward. This is an over-statement as regards many types of radial plates, which can be recognized by one who is familiar with characters of the whole crinoids, but it is sufficiently true as a generalization applied to dissociated facetals of unknown generic affinities. There is a definite relation, of course, between the general plane of a facet and the curved surface beneath it, but if the precise orientation of this surface

in the crinoid cup is not known (and outline of the plate as a whole may not satisfactorily establish this), it is obvious that the attitude of the articular facet in the whole crinoid is more or less conjectural.

For purposes of description of facetals it is necessary, or at least desirable, to adopt some standard methods of orientation. The facet area, which is distal, is placed upward. The length of the ossicle may be defined as the distance along the median longitudinal profile from the proximal tip to the margin of the facet, and the height as the vertical distance from the proximal tip to the plane tangent to the opposite extremity when the midpoint of the outer margin of the facet is held directly above the proximal tip. The angle of the facet may be measured with the plate in this position, being recorded preferably in terms of the vertical line already indicated. The length of the facet is measured from the midpoint of the outer margin to a line tangent to the innermost points. The width of the facetal plate should be measured along its curvature at the widest point.

Classification of Facetals.—Subdivision of facetals can seemingly be established best on presence or absence of a transverse ridge on the facet, and secondarily on the basis of relative width of the facet and certain other characters. No effort is made here to indicate and describe types of facetal ossicles which are not well represented in Upper Carboniferous materials, and only a few representative examples from this source are given. (See Figure 10.)

Subdivision LIOCRINARTHRA Moore

Ossicles bearing an articular facet that lacks a transverse ridge and associated features indicative of well developed muscular articulation, outline of facet generally rounded; perforation for the dorsal canal may be present.

Subdivision LOPHOCRINARTHRA Moore

Ossicles bearing an articular facet with well developed transverse ridge, outline of facet strongly rounded on outer or proximal side.

FIG. 10. SKETCHES OF A FEW TYPES OF FACETALS FROM PERMIAN ROCKS OF TIMOR

These are radial plates representing unknown genera and species of crinoids. (After Wanner).

Main Group STENOLOPHARTHRA Moore

Width of the articular facets distinctly narrower than that of the plates, the facets bearing a transverse ridge.

Group HOPLARTHRA Moore

Facets distinctly narrower than the greatest width of the ossicle and horseshoe-shaped or at least somewhat narrowly rounded on the proximal side; the angle between the plane of the facet and the surface beneath it is generally large; lateral furrows, oblique ridges, and other markings of the ligament areas weakly defined or absent, indicating that muscular articulation is incompletely developed. Group-type *Hoplarthrum canalis* Moore.

HOPLARTHRUM CANALIS Moore

Plate II, figures 7a-d

Plate U-shaped, deeply notched at the distal edge, facet strongly rounded proximally, the area of the facet separated from the outer non-articular surface by a distinct angulation. The greatest width of the facet area, located at the distal edge, is about seven-tenths of the greatest width of the plate. The transverse ridge is distinct but rather weakly developed; it is not straight, for the two halves meet at a very obtuse angle, measuring about 155°. The outer marginal ridge is bordered by faint, short denticles arranged normal to the ridge, but there are no other markings in the gently concave outer ligament area. The inner ligament area contains broad, shallow depressions in the general position of the lateral furrows and there are faint grooves marked by curved cross-striae in the muscle areas. A very short intermuscular furrow appears at the base of the intermuscular notch. The outer surface of the plate is smooth. On the inner side of the holotype specimen there are well marked ridges formed by thickening of the plate; these rise near the base of the intermuscular notch and radiate to the lower angles of the plate where they are most prominent. The ridges appear also on the paratype but are much fainter. The suture faces along the sides and proximal border are marked by numerous irregularly arranged fine denticles on the exterior edge and are indented by long shallow pits near the interior edge.

Measurements of the holotype specimen are as follows: width of plate, 19.5 mm.; length of plate (midpoint of outer marginal

ridge of facet to proximal tip of plate), 8.2 mm.; height of plate, 12.5 mm.; length of facet at midline, 5.3 mm.; greatest width of facet (distance between lateral lobes), 14.4 mm.; depth of intermuscular notch, 5.5 mm.; distance between extremities of transverse ridge, 11.0 mm.; length of outer ligament area, 3.5 mm. Angle between midline of outer surface and midline of facet, 100°; between midline of outer surface and plane of the edges of facet, 125°.

These are radial plates of a poteriocrinitid genus.

Occurrence.—Cap rock of Mineral coal, about 140 feet below top of Cherokee shale, Des Moines series, Pennsylvanian (Upper Carboniferous); sec. 25, T. 30 S., R. 24 E., about two miles west of Pittsburg, Kans. A. M. Brooks, collector.

Types.—Holotype, Kansas Univ. no. 0–60462; paratype, no. 0–60462a.

HOPLARTHRUM TENUE Moore, new section

Plate II, figures 4a-d

These ossicles resemble the ones last described in the unornamented smooth exterior, narrowness of the facet, and relative thinness of the plates. The widest part of the ossicle is between the lower lateral angles in this section, well below midheight of the plate, whereas in *Hoplarthrum canalis* the greatest width is near the summit. The facet is comparatively short in *Hoplarthrum tenue*, and the transverse ridge is very distinct and straight. The outer ligament area is well excavated; fine denticles occur along the inside of the outer marginal ridge. The inner ligament area shows a narrow oblique ridge on each side of the sharply defined intermuscular furrow; these ridges separate triangular shallow depressions in the position of the lateral furrows from narrow strips that represent the muscle areas. The intermuscular notch is shallow. The inner side of the plates is smooth and there are no perceptible radially disposed thickenings. The lateral and proximal suture faces are very narrow, for the plates are thin; they are marked by fine denticles that tend to run normal to the outer face of the plate but in part are irregular. This

is a common type of facetal, being represented by more than a dozen specimens in the small collection of ossicles from the locality west of Pittsburg, Kans.

Measurements of the holotype, a very well preserved but small plate, and of a fairly large paratype are as follows, the smaller figures referring to the holotype: length of facetal, 6.6, 12.3 mm.; height of facetal, 7.5, 14.3 mm.; width of facetal, 10.0, 17.4 mm.; width of facetal at summit, 8.2, 13.5 mm.; length of articular facet, 2.5, 4.2 mm.; length of outer ligament area, 1.0 2.0 mm.; length of transverse ridge, 3.8, 6.4 mm.; width of facet at inner margin, 4.8, 8.4 mm.; angle between midline of outer surface and plane of rim of facet, 122° in holotype, 118° in paratype.

Occurrence.—Cap rock of Mineral coal, about 140 feet below top of Cherokee shale, Des Moines series, Pennsylvanian (Upper Carboniferous); sec. 25, T. 30, S., R. 24 E., about two miles west of Pittsburg, Kans. A. M. Brooks, collector.

Types.—Holotype, Kansas Univ. no. 0–60463; paratypes, no. 0–60463a-f. Other typical specimens from the same horizon and locality, U. S. Nat. Museum no. 147334.

Group ENGONIARTHRUM Moore

Ossicles with facets resembling those of *Hoplarthrum* in the presence of inward extensions of the outer surface on each side of the facet, which is thus distinctly narrower than the greatest width of the plate, but the proximal margin of the facet is only very gently rounded and there are well marked angulations in the outline of the facet at ends of the transverse ridge. A ligament pit may occur in the outer ligament area but strongly defined ridges and furrows are not developed. Plates typically thick. Group-type, *Engoniarthrum granulosum* Moore.

ENGONIARTHRUM GRANULOSUM Moore

Plate III, figures 2a-c

This very distinctive type of facetal plate is not common in Upper Carboniferous rocks, but specimens very similar to the

one here described have been found at several localities and horizons.

The general outline of the plate is subelliptical, the greatest width being about 1.5 times that of the longest dimension normal to this. The widest part is located slightly above the position of the transverse ridge, and the moderately strong inward slope of the lateral suture faces indicates that the midline of the outer surface is outwardly tilted from the proximal tip and the plane of the facet very steep when the plate is oriented as in the crinoid cup. The non-articular surface is convex and its edges along each of the sutures bows outward so that the margin appears scalloped. Closely spaced granules ornament the exterior below the facet and extend a short distance above the ends of the transverse ridge at the sides of the facet; this ornamentation does not extend on the shoulders all of the way to the inner margin. At midlength of the outer surface there is a narrow, slightly arcuate ridge bearing tubercles, one of which happens to be prominent.

The facet is asymmetrical in outline, the left margin curving upward and inward more strongly than the one on the right. The lower margin of the facet curves gently, the outer ligament area being short, undepressed, and entirely covered by fine, slightly irregular denticles trending normal to the outer margin. A moderately deep slitlike ligament pit occurs next to the center of the transverse ridge on the outer side. The inner ligament area is smooth and featureless, except for barely perceptible depressions in the position of the lateral furrows and muscle areas. The intermuscular notch, which is broad and deep, is confluent with a narrow, well marked intermuscular furrow that reaches almost to the transverse ridge.

The interior surface of the plate is smooth. There is a rounded shelf just below the intermuscular notch. The plate is relatively thick, especially in the region near the lower margin of the facet. The suture faces bear a zone of irregular ligament denticles about one millimeter wide next to the outer but not the inner border of the faces; the remaining area of the faces is smooth.

Measurements of the holotype specimen are as follows: length,

4.5 mm.; height, 6.6 mm.; width, 11.4 mm.; distance from proximal tip to inner edge of facet, 8.0 mm.; length of facet, 5.3 mm.; width of facet, 9.0 mm.; length of outer ligament area, 2.8 mm.; ligament pit, 3.0 mm. wide, 0.3 mm. long; depth of intermuscular notch, 1.0 mm.; length of transverse ridge, 9.0 mm.; thickness of plate, measured on suture face, greatest, 4.0 mm., at proximal tip, 1.4 mm. Angle of facet plane to midline of outer surface, 120°.

This is a radial plate belonging to a poteriocrinitid similar to *"Cyathocrinus" stillativus* White.

Occurrence.—Hickory Creek shale member, Plattsburg limestone, Lansing group, Missouri series, Pennsylvania (Upper Carboniferous); brick pit at Sycamore, Montgomery County, Kans. R. C. Moore, collector.

Type.—Holotype, Kansas Univ. no. 0–60051.

ENGONIARTHRUM LINEATUM Moore

Plate II, figures 5, 6; plate III, figures 3, 4a, b

Several specimens of this ossicle, showing constant characters among themselves but differing sufficiently from the last described form to permit identification easily, indicate the manner in which dissociated crinoid plates may be used in stratigraphic studies, for these come from a horizon that is considerably lower than the Plattsburg limestone.

The general outline of the ossicles is like that of *E. granulosum* but the average size of the plates is much smaller and angularity is much more pronounced. Just below the middle of the facet area two narrow, sharp-crested ridges rise abruptly and extend with divergent course to the midpoints of the lower suture margins of the plate. Less distinct ridges reach from points near the extremities of the transverse ridge to the middle of the lateral sutures. The surface between these ridges is ornamented with granules that are much finer than in the last described section of facetals. The suture faces have a narrow raised rim on which no denticles are seen, and the appearance is altogether unlike that of the faces of *E. granulosum.* Characters of the facet are not sufficiently different from those

previously noted in the Plattsburg ossicle to call for special description.

Measurements of the holotype show average dimensions: length, 3.4 mm.; height, 4.2 mm.; width, 6.0 mm.; length of facet, 2.3 mm.; width of facet, 4.0 mm.; length of outer ligament area, 0.7 mm.; depth of intermuscular notch, 0.8 mm.; greatest thickness on suture face, 1.0 mm., at proximal tip, 0.35 mm.

The facetals here described, and *of E. granulosum*, belong to the same type of crinoid as *"Cyathocrinus" stilllativus* White, from the Iola limestone west of Humboldt, Kans., but they clearly represent different species.

Occurrence.—Near top of Oologah limestone, Des Moines series, Pennsylvanian (Upper Carboniferous); Garnett quarry, about 7 miles northeast of Tulsa, Okla. Bob Stevens, collector.

Types.—Holotype, Kansas Univ., no. 0–45891; paratypes, nos. 0–45891a-k.

Main Group PLATYLOPHARTHRA Moore

Articular facets equal to the greatest width of the plates, a transverse ridge present on the facet.

Group MACROCRINARTHRA Moore

Ossicles with facet equal in width to the greatest width of the plate, angles between the transverse ridge and lateral suture faces 90° or slightly greater; outer ligament area of facets generally very short and rather strongly depressed; inner ligament area broadly concave or nearly flat, lateral furrows and oblique ridges mostly weak or absent. Group-type, *Macrocrinarthrum corrugatum* Moore.

MACROCRINARTHRUM CORRUGATUM Moore

Plate II, figures 9a-c

Ossicles consisting of the radial plates of a globose or bowl-shaped crinoid that is generically and specifically undetermined are numerous in collections from basal Missouri shale in southern Kansas. They are described here under the section name *corrugatum*.

Facet area barely visible in front view of ossicles, because the angle between the plane of the non-articular surface and that of the facet is only a little more than 90°. The angle between a plane that passes through the midpoint of the outer marginal ridge of the facet and the proximal tip of the plate, parallel to the transverse ridge, and the plane intersecting the marginal ridge and inner edges of the facet measures 108°. A right angle occurs between the transverse ridge and the lateral sutures. The outline of the front of the plate is pentagonal, with the width distinctly greater than the length. The surface is marked by a prominent shelflike projection that occurs slightly below the facet area, by low swellings of irregular form on the lower part of the plate that tend to be arranged parallel to the borders of the ossicle, and by small granules or pustules that are thinly scattered, about 10 to 15 occurring in a space of 4 square millimeters.

The transverse ridge is straight, strongly elevated, sharp-crested, and very prominent. It is edged on the inner side by denticles that run normal to the ridge, those near the extremities being distinctly longer than the ones near the center. The outer ligament area is deeply excavated and very short; its mid-portion on the distal side contains the ligament pit, and a median ridge is present. The inner ligament area is broadly concave. The slope from the transverse ridge is smooth, but that from the inner margin of the facet, representing the muscle areas, is corrugated; a narrow groove near each of the lateral extremities may indicate the lateral furrows, but these are not clearly differentiated and bear no denticles. A very broad and shallow intermuscular notch indents the inner margin of the facet. A narrow, well marked intermuscular furrow reaches nearly to the transverse ridge.

The inner surface of the ossicles is smooth. View of the plates from this side indicates the shelflike inward projection of the facet area. The suture faces are plane and perfectly smooth except for a belt of fine irregular denticles near the outer border.

Measurements of the holotype specimen follows: length, 15.5 mm.; height, 17.0 mm.; width, 21.8 mm.; length of facet, 6.7 mm.; length of outer ligament area, 1.5 mm.; ligament pit, 9.0

mm. wide, 1.0 mm. long, 1.2 mm. deep; depth of intermuscular notch, 2.0 mm.; thickness of plate measured on suture face at proximal margin, 1.0 mm.

Occurrence.—Checkerboard? limestone, near base of Coffeyville shale, Ochelata group, Missouri series, Pennsylvanian (Upper Carboniferous); old brick pit in northwest part of Coffeyville, Kans. R. C. Moore, collector.

Types.—Holotype, Kansas Univ. no. 0–46074; paratypes, nos. 0–46074a-m. Several dozen additional specimens belonging to this section have been collected from the locality at Coffeyville.

MACROCRINARTHRUM TUBERCULATUM Moore

Plate II, figures 8 a-c; plate III, figure 10

The outline of this section of facetals is almost identical with that last described, but the average size of the plates is a little smaller. Chief distinguishing character is the strongly tubercled nature of the surface. The angles between the transverse ridge and the lateral sutures are very slightly greater than 90°, the greatest width of the plates being located between the two lower angles. This does not invalidate the criterion of facet width in respect to plate width, for this refers to the summit portion of the ossicle, and in most facetals this is the region of greatest width. The profile of the midline of the plate is nearly straight, ignoring the tubercles, from the proximal tip to a point just below the border of the facet where there is a slope inward, the sloping area lacking tubercles. The facet is divided sharply by the very prominent straight transverse ridge, the outer ligament area being short and rather strongly depressed and the inner ligament area being also moderately short and concave. There is an outward slope from the crest of the transverse ridge to the outer marginal ridge that is notably steeper than the inclination from the inner edge of the facet to the transverse ridge. The interior of the plate is evenly curved and smooth. The suture faces are plane except for denticles near the outer edges; the denticles are arranged in groups beneath the furrows of slight crenulations that mark the margin of the sutures; the average

trend of the denticles is parallel to the outer face of the plate rather than at right angles to it.

Measurements of the holotype specimen are as follows: length, 14.0 mm.; height, 16.0 mm.; greatest width, 21.0 mm.; width at transverse ridge, equal to length of this ridge, 19.3 mm.; length of facet, 5.5 mm.; length of outer ligament area, 1.8 mm.; ligament pit, 1.2 mm. deep, width (borders not sharply defined), about 7.0 mm.; depth of intermuscular notch, 1.9 mm. Angle between midline from proximal tip to margin of facet and plane of the rim of the outer ligament area, 120°; angle between midline and plane defined by midpoint of the outer marginal ridge and inner border of facet, 97°.

Occurrence.—Cap rock of Mineral coal, about 140 feet below top of Cherokee shale, Des Moines series, Pennsylvanian (Upper Carboniferous); sec. 25, T. 30 S., R. 24 E., about two miles west of Pittsburg, Kans. A. M. Brooks, collector.

Types.—Holotype, Kansas Univ., no. 0–60464; paratypes, nos. 0–60464a-d.

Group BUNARTHRA Moore

Ossicles with facet equal to greatest width of the plate; outer ligament area reduced to a mere slit; inner ligament area with strongly marked lateral furrows and oblique ridges; lateral margins of plate converging slightly downward; inner surface marked by very prominent ridges that diverge from the base of the intermuscular notch to the angles of the plate. The last mentioned character appears to be a specially important and distinctive one. Group-type, *Bunarthrum septatum* Moore.

BUNARTHRUM SEPTATUM Moore

Plate III, figures 1a-d

Outline of outer surface of ossicle pentagonal, distinctly wider at the top than below; no part of facet visible in front view. A border zone at the sides and along the proximal margin of the plate is faintly differentiated from the interior portion, which rises to a bulbous convexity, highest not far below the facet.

The outer marginal ridge of the facet is unusually strong, or at least it appears prominent because of the depressed area between it and the bulge of the surface previously mentioned. The outer ligament area is a wide but extremely short slit that is moderately excavated and marked by numerous fine denticles. The ligament pit interrupts the straight-line continuity of the transverse ridge, for the ridge bends rather abruptly around it inwardly. The chief features of the inner ligament area are the long, steep-walled lateral furrows, which run parallel to the transverse ridge from its extremities to the center, and the oblique ridges that merege on the inner side with elevated flat muscle areas. There is a very broad shallow intermuscular notch.

The inner face of the plate is divided into four triangular compartments by the flangelike projection of the facet and three elevated septa that radiate from the base of the intermuscular notch to the angles of the plate. The depth of these compartments, measured normal to the general plane of the plate, is greater near the suture faces than at the center. The sutures at the sides and bottom of the plate are straight, viewed from the front or rear, but appear scalloped in edge view; the faces are extremely thin but are wide enough to carry slitlike ligament grooves. The outer surface is smooth.

Measurements of the holotype are as follows: length, 8.0 mm.; height, 7.0 mm.; width, 12.2 mm., length of facet, 3.6 mm.

The strikingly prominent walls on the inner side of the plate are a chief distinguishing character of this ossicle.

Occurrence.—Stanton limestone, Ochelata group (includes Lansing and additional beds of northern Kansas), Missouri series, Pennsylvanian (Upper Carboniferous); railroad cut one mile southwest of Wayside, Montgomery County, Kans. Paul McGuire, collector.

Type.—Holotype, Kansas Univ., no. 0–60181.

Division CRINOPOLYGONA Moore (Polygonals)

Crinoid ossicles that lack identifiable characters showing basis for placement in other morphologic divisions are classed as Polygonals. Such plates lack a central perforation and radiating

ridges like those of Columnals; they bear no marks of a stem impression, as in most Apicals, nor evidences of articulation corresponding to the facets of Facetals and Pinnates; and there is no distinctive feature of form or appearance that permits recognition of a certain type of Tegminal plate.

It is probable that a large majority of ossicles among Polygonals, as here defined, have little or no value in stratigraphic paleontology. They lack characters for differentiation from ossiles found at other horizons, and they may then be ignored. The division is not quite a waste-basket, however, for it includes plates such as the basals of late Paleozoic inadunate crinoids that can be recognized easily. Some of these may be as useful as other types of ossicles. The name of the division is derived from the Greek *krinon*—lily (crinoid) and *polugonon*—polygon; other roots used in names for assemblages are *aglaos*—decorated, *bounos*—hill, *leios*—smooth, *lophos*—ridge, and *schedon*—almost.

Morphologic Features and Classification.—At first thought one may well doubt the existence of significant morphologic features of Polygonals and need for discussion of classification. Certainly, not very much can be observed that calls for detailed description or names of special parts, and if significant structures are lacking, there is much difficulty in classifying these ossicles in subordinate assemblages. (See Figure 11.)

Polygonals have shape. Mostly but not invariably, these ossicles have much greater extent in some directions than others, and the largest surface areas are generally those of the outer and inner sides. Thickness is measured normal to these sides, generally along a suture face. Even if the outer and inner sides of a plate belonging to a crinoid dorsal cup or tegmen are smooth, it is ordinarily possible to recognize the suture faces by characters such as planeness, ligament pits or denticles, and outline of the plate as a whole. The outer surface may be recognized by its convexity and in many cases by presence of decoration. Many polygonals have a perfectly symmetrical form, and this, together with the relative length and position of suture faces, may establish orientation, indicating which are the proximal and distal margins. It is then possible to designate length and width in the customary meaning as applied to crinoid plates, which takes

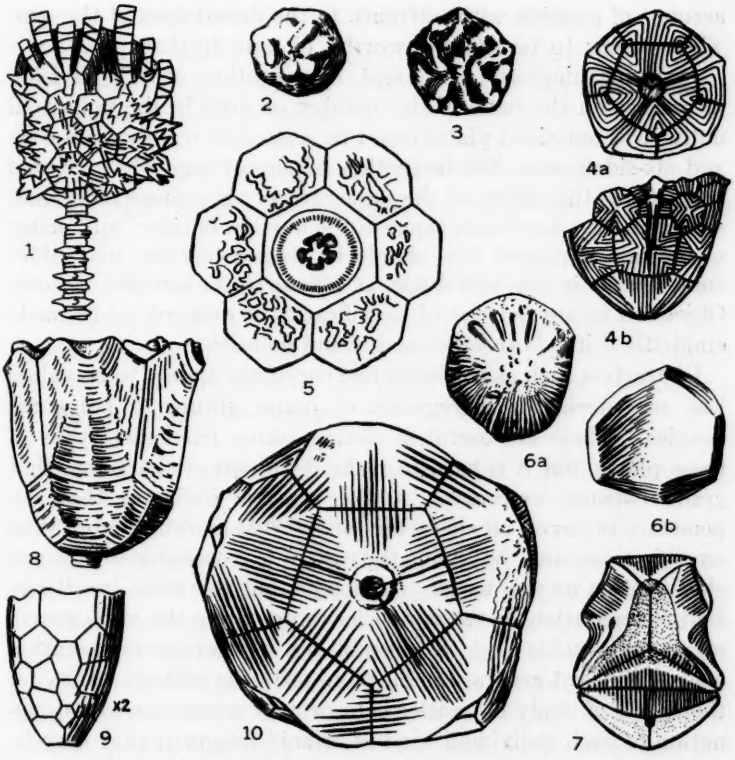


FIG. 11. CRINOID CUPS AND OSSICLES OF SIMPLE AND SPECIALIZED NATURE, ILLUSTRATING PROBLEMS IN DISTINGUISHING INDIVIDUAL OSSICLES

Surface markings may furnish basis for recognition of several forms, but certainly not in the case of dissociated ossicles from the cup shown in Fig. *9*. Polygonals are represented in all of the figures except *8*. All of the cups are monocyclic, but if apicals were found separated they could be identified with reasonable certainty as basals only in the case of Fig. *5*; the six polygonal plates surrounding the apical disc in Fig. *5* consist of radials and one interradial (anal) plate.

1, *Melocrinus calvini* (Devonian); *2*, *Polygonal* (Permian); *3*, *Polygonal* (basal plate identified as *Eupachycrinus* sp. but probably belonging to *Ethelocrinus*, Pennsylvanian); *4*, *Macrostylocrinus meeki* (Silurian); *6*, *Polygonal* (unknown genus, Permian); *7*, *Halysiocrinus perplexus* (Mississippian); *8*, *Platycrinus glyptus* (Mississippian); *9*, *Acrocrinus intermedius* (Mississippian); *10*, *Marsipocrinus striatissiumus* (Silurian). (After Wachsmuth and Springer, *1*, *4*, *5*, *7*, *8*; after Springer, *9*, *10*; after Wanner, *2*, *6*; after Girty, *3*).

account of position with reference to the dorsal apex of the cup. There seems to be nothing worthy of note further.

It is meaningless to attempt classification of this division of ossicles on the basis of the number of sides in the polygonal outline. Four-sided plates could be separated readily from five- and six-sided ones, but inspection of almost any whole crinoid calyx shows that plates of the same category in a single individual specimen may have such range in the number of sides; and plates of the same category that should be classed together may differ considerably in size and shape, as well as in the number of sides. Objection to any scheme of classification is properly to be made emphatic if it is both burdensome and pointless.

Characters such as thickness and curvature appear to be valueless as criteria for segregation of major groups of polygonal ossicles. These are useful in distinguishing particular types of these plates, but it is hard to make definition of characters that grade between extremes. Actual practice indicates that dependence is placed on characters of external markings more than anything else, and that being the case, it is reasonable to attempt classification on this basis. Argument that this must inevitably lead to separations between ossicles representing the same genera of whole crinoids and to assemblages of ossicles representing widely different genera, families and orders is without value, for the object of study of ossicles is to provide separation and designation of each individual kind of crinoid fragment that may be useful in stratigraphic work. Species of crinoids bear more or less distinctive characters of surface markings and species are likely to have a short stratigraphic range. Forms that possess readily identifiable peculiarities of markings are useful and those that do not will have to be neglected. It may be suggested that if this view concerning classification on the basis of surface markings seems best for treatment of polygonals, logically the same method should be employed in dealing with other divisions of ossicles. Perhaps this is so, but these other assemblages show significant structural features that are also useful in classification and surface markings are taken into account also.

Main Group LIOPOLYGONA Moore

Polygonal ossicles with smooth, unornamented exterior; this assemblage may include strongly convex plates, but not those with protuberant bosses or spines.

Main Group AGLAOPOLYGONA Moore

Polygonal ossicles characterized by some sort of external decoration.

Group SCHEDAGLAOPOLYGONA Moore

Polygonals with a surface pattern consisting mainly of low, partly discontinuous swellings and shallow grooves arranged parallel to the margins of the plate. Group-type, *Schedaglaopolygonum corrugatum* Moore.

SCHEDAGLAOPOLYGONUM CORRUGATUM Moore

Plate III, figures 9a, b

Large plates with gentle convexity that in most cases are symmetrical in outline. These symmetrical plates appear to be regular pentagons with sides of uniform length, but one of the sides really consists of two suture faces that are separated by a barely perceptible projection. The double suture face side marks the proximal edge of the plate. Plates of slightly asymmetrical outline, about the same in size as those just considered and matching them in surface markings, evidently belong to the same species of crinoid. Comparison with the cup of inadunates of similar age and general form of plates shows that these polygonals are basal plates belonging to an undescribed species, probably of *Ethelocrinus*. Characters of outline permit identification of the posterior basal and right posterior basal; the symmetrical plates belong to other parts of the circlet.

The surface markings consist of low, discontinuous ridges, about a millimeter in width, separated by shallow furrows of similar width; these are arranged parallel to the edges of the plate. The ridges tend to be interrupted near radial lines from

the center to angles of the plate, and discontinuous radial ridges occur in these positions. The outer margin of the suture faces is faintly crenulated, and groups of irregular denticles appear on the suture faces beneath furrows of the crenulations.

Measurements of a typical specimen, designated as holotype of the section, are as follows: length, 22.5 mm.; width, 25.5 mm.; convexity (distance from plane intersecting tips at angles on inner side to high point of outward curvature), 6.5 mm.

Occurrence.—Checkerboard? limestone, near base of Coffeyville shale, Ochelata group, Missouri series, Pennsylvanian (Upper Carboniferous); old brick pit in northwest part of Coffeyville, Kans. These plates are numerous. R. C. Moore, collector.

Types.—Holotype, Kansas Univ. no. 0–46074; paratypes, nos. 0–46074a-g.

Group LOPHAGLAOPOLYGONA Moore

Polygonals characterized by external ornamentation consisting of well marked irregular rugae, more or less elevated and closely spaced; plates generally rather thick. Group-type, *Lophaglaopolygonum tenuirugosum* Moore.

LOPHAGLAOPOLYGONUM TENUIRUGOSUM Moore

Plate III, figures 6a-c, 7a-c

Description of this form of polygonal ossicle is based on two specimens, a relatively large asymmetrical plate that is judged to be a posterior basal, and a small symmetrical plate that has typical form characters of the left posterior, left anterior or right anterior basal plate of a genus like *Ethelocrinus*. The outer surface of both specimens is marked by a close-spaced pattern of somewhat fine irregular ridges of different length, many being reduced to nodelike form. This pattern is much finer than appears on the plates of *Ethelocrinus magister* (Miller and Gurley), *E. sphaeralis* (Miller and Gurley), or *E. verrucosus* (White and St. John), most closely resembling the decoration observed in *E. hispidus* Moore and Plummer. The ridges are more flexuous and even in the plates here described than in those of the last-

named form. The ossicles in hand are unusually thick. The interior surface is smooth, but the larger specimen shows faint ridges extending from the center to the angles of the plate.

Measurements of the large specimen, designated as holotype, are as follows: length, 22.5 mm.; width, 18.0 mm.; convexity, 7.0 mm.; thickness (measured at a short distance from suture face), 4.0 mm.

Occurrence.—Missouri series, Pennsylvanian (Upper Carboniferous); southwestern Iowa. C. A. White, collector. The precise horizon and locality are not recorded.

Types.—Holotype, Univ. Iowa, no. 3424; paratype, no. 3424a.

Group BUNAGLAOPOLYGONA Moore

Polygonals distinguished by external ornamentation consisting of well defined round tubercles as the most prominent feature, with or without finer decoration. Group-type, *Bunaglaopolygonum tuberculatum* Moore.

BUNAGLAOPOLYGONUM TUBERCULATUM Moore

Plate III, figures 8a, b

The general size and outline of these plates correspond almost exactly to those designated as *Schedaglaopolygonum corrugatum*, and there can be no doubt as to their identity as basal plates, very probably belonging to a species of *Ethelocrinus*. The distinctive feature of this section of polygonals is the evenly spaced, prominent round tubercles that are distributed over all of the outer surface. The tubercles have a height of about one millimeter, and their diameter is about the same. The spaces between them are slightly more than a millimeter, on the average, and are devoid of ornamentation. The interior of the plates is smooth. The thickness is moderate. Suture faces show bundles of irregular denticles.

Measurements of the holotype are as follows: length, 20.0 mm.; width, 21.5 mm.; convexity, 6.0 mm.; thickness, measured on suture face, 1.5 mm.

Comparison with illustrations of *Ethelocrinus tuberculatus*

(Meek and Worthen), from beds of lower Pennsylvanian age in Illinois, suggests that the ossicles here described probably represent this species. The horizon from which the plates were collected is about the same as that in Illinois, so far as known.

Occurrence.—Cap rock of the Mineral coal, about 140 feet below the top of the Cherokee shale, Des Moines series, Pennsylvanian (Upper Carboniferous); sec. 25, T. 30 S., R. 24 E., about two miles west of Pittsburg, Kans. A. M. Brooks, collector.

Types.—Holotype, Kansas Univ. no. 0–60465; paratypes, nos. 0–60465a-f.

Division CRINOSTEGAE Moore (Tegminals)

Crinoid ossicles that are identifiable as forming part of the calyx above the dorsal cup are classed as tegminals. Such plates are specialized or distinctively ornamented elements of the tegmen or anal sac of some camerates, and especially those of fistulate crinoids among the inadunates. As already indicated, some plates of the tegmen must be classed with Polygonals, if treated at all, for they lack characters on which their skeletal position may be recognized. The name of the division is derived from the Greek *krinon*—lily (crinoid) and *stege*—roof; names for various assemblages of tegminals are derived from *akanthos*—spine, *aulos*—groove, *geison*—eaves, and *somphos*—porous.

Morphologic Characters and Classification.—Attention here may be confined to ossicles of the tegmen that are known to have distinguishing features and that may be of use in studies of dissociated ossicles or fragments composed of several ossicles. (See Figure 12.)

One type of ossicle that appears to be confined to the anal sac of crinoids is marked by indentations of the margin and suture face on one or more sides. These indentations are found commonly to match similar depressions on adjoining plates, so that they appear as pore openings or slits that cross suture lines. In some cases the perforations are concentrated near angles between plates, but in others this is not so. A few inadunates possess a special pore-bearing plate termed a madreporite. Isolated ossicles of the types mentioned can be identified by their pore-bearing

nature, and in addition, an arrangement of plates and characters of ornamentation that are not seen in the dorsal cup may aid in recognition. Even a small fragment of the anal tube of *Aesiocrinus*, for example, can be distinguished readily both as to its morphologic nature and its generic relations. The anal sac plates of some hydreionocrinids appear starlike, and at the center of the several-rayed star may be a low spine.

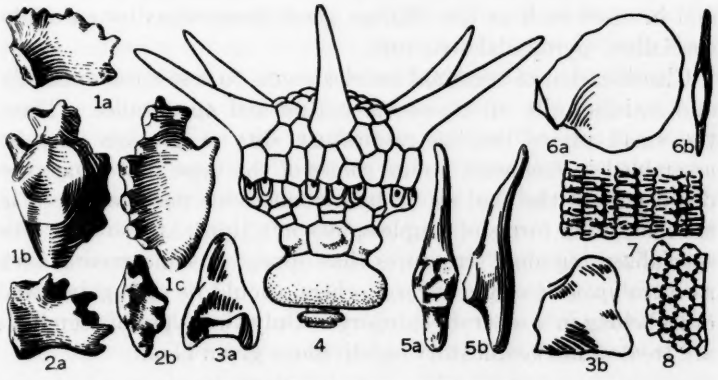


FIG. 12. OSSICLES OF THE TEGMEN

Figs. *1–6* show various spinose plates of the tegmen, or presumably belonging here; figs. *7* and *8* illustrate plates of the anal sac of inadunate crinoids with respiratory pores. *1, 2, 5*, Ossicles belonging to unknown crinoids, Permian of Timor; *3*, "wing plate" of *Pterotocrinus coronarius* (Mississippian); *4*, calyx of *Dorycrinus missouriensis* (Mississippian); *6*, "wing plate" of *Pterotocrinus depressus* (Mississippian); *7*, portion of the anal sac of *Hallocrinus ornatissiumus* (Devonian); *8*, portion of the anal sac of *Aulocrinus agassizi* (Mississippian). (After Wanner, *1, 2, 5*; after Wachsmuth and Springer, *3, 4, 6*; after Goldring, *7*; after Springer, *8*).

Spines of various shape and length are observed on the tegmen of some crinoids. These are identifiable as tegminal rather than brachial by their peculiarities of shape and the nature of suture faces at the base; there are no evidences of muscular articulation. Peculiarly specialized tegminal spines, as in *Callicrinus* and *Pterotocrinus* (Figs. 3, 12) and the tegminal compartments for the arms, as in *Eucalyptocrinus* are familiar to most paleontologists. A very common type of spine that projects laterally

from the mushroom-like top of the sac in hydreionocrinids is characterized by the blade form of the base and the occurrence of somewhat dendritic grooves near the area of attachment, on the under side. These grooves correspond to the respiratory pores observed on smaller tube plates.

Another type of tegminal plate that is identifiable, in some cases at least, comprises the orals, primitively triangular ossicles that surround the mouth. These may be determinable by their shape, and in cases such as the Silurian genus *Gazacrinus* by an oddly specialized pyramidal structure.

Classification of tegminal ossicles seems to rest most naturally and satisfactorily on structural nature and appearance. Thus, the small plates bearing respiratory slits or grooves may be assembled in one main group, spines of the type that fringe the distal part of the anal sac in hydreionocrinids may be placed in another, other forms of simple spines in a third, and so on. The specialized tegminal structures that appear in some genera, such as *Eucalyptocrinus* and several others, should be segregated, and orals belong in a separate category. Only two types of tegminals are treated in classificatory subdivisions given here.

Main Group SOMPHOSTEGAE Moore

Ossicles of the anal sac of crinoids that are primarily characterized by presence of pore-grooves or marginal slits, presumably respiratory in function. Spine-bearing plates are not referred to this main group unless the spine is considered an accessory feature rather than a dominant one.

Group AULOSOMPHOSTEGAE Moore

Tegminals with strongly marked deep slits that radiate in several directions from near the center of the plate to the margins. Group-type, *Aulosomphostega incisa* Moore.

AULOSOMPHOSTEGA INCISA Moore

Plate IV, figure 6

The specimen on which description of this section is based shows two dozen or more ossicles that are preserved in approxi-

mately undisturbed position as regards relations to one another. Apparently they belong at the top of the anal sac of an unknown fistulate crinoid, for one of the plates bears a central rounded spine that is distinctly larger than the tubercle-like nodes at the middle of others, and such a terminal spine is seen at the distal extremity of some anal sacs. The most interesting feature of the plates is the close-spaced pattern of deeply incised slits that extend inward from all sides. The slits are arranged in groups of parallel incisions, the longest ones being in the center of each group, for where adjoining groups interfere there is not room for long slits. The number of groups on a plate is dependent on the size of the plate, small ones having as few as four groups and large ones as many as eight. The slits terminate inward at the base of a small boss or low spine, already mentioned. Originally these ossicles fitted tightly together without gaps at the angles or along edges, this condition being preserved on part of the specimen, but weathering of the margin of some of the plates has given them a rounded form.

The largest plate has a diameter of 6.5 mm. and the smallest about 3.0 mm. The large spine has a diameter of 2.5 mm. near the base and a height of about 3.0 mm. The thickness of the plates is about 1.0 mm. As seen from the under side, the middle part of the plates is smooth, the outer part strongly corrugated; the edges appear stelliform in outline, the long slits of the exterior lying opposite projections on the interior margin.

Occurrence.—Cap rock of Mineral coal, about 140 feet below top of the Cherokee shale, Des Moines series, Pennsylvanian (Upper Carboniferous); sec. 25, T. 30 S., R. 24 E., about two miles west of Pittsburg, Kans. A. M. Brooks, collector.

Type.—Holotype, U. S. Nat. Museum no. 147334.

Main Group ACANTHOSTEGAE Moore

Ossicles of the tegmen consisting primarily of simple spines, generally elongate.

Group GISACANTHOSTEGAE Moore

Spines of the type occurring as a fringe around the distal portion of the anal sac in hydreionocrinids are included in this

group. They are distinguished by the bladelike expansion of the base, suture faces being present around the edges of the blade. The surface that reaches farthest proximally is the upper one, the point of the spine being directed laterally from the sac. The base of the lower surface bears irregular grooves. Group-type, *Gisacanthostega expansa* Moore.

GISACANTHOSTEGA EXPANSA Moore

Plate IV, figures 4a-c

Outline of spine arrow-shaped, greatest width a little more than half of the length in the holotype, but this varies slightly in different specimens. From the widest point, located at about midlength, the margins converge distally to a sharp point that is accentuated by a constriction a few millimeters distant from the tip; the distal edges are sharply rounded and somewhat flexuous. The edges of the spine also converge proximally from the midlength, but these edges are perfectly straight suture faces; the proximal extremity is a blunt angle made by the intersection of two short suture faces. The lower surface of the spine does not reach as far proximally as the upper and there is a grooved area at this edge reaching about 7 mm. toward the middle of the area. The distal part of the under surface shows a median rib that appears as a continuation of the sharpened tip of the spine and as a support for it, but this feature is not seen on the upper surface. The suture faces are divided by a furrow into upper and lower portions, but a narrowing and termination of the furrow before the distal ends of the faces are reached brings the halves together.

Measurements of the holotype specimen are as follows: length, 30.0 mm.; greatest width, 16.5 mm.; width at outer angles near proximal end, 9.4 mm.; vertical distance from upper to lower surface near proximal end, 6.5 mm. The suture faces on the lower part of the plate are a little closer together in the proximal region than those on the upper part, as may be seen by viewing the spine from below; the suture faces on opposite sides can both be seen at once, whereas if the spine is viewed from above no part

of any suture face is visible. This means that the spine was directed slightly downward as well as outward, a conclusion that is supported by observation of the upper and lower surfaces in profile; the upper profile slopes distinctly toward the distal region and is convex upward, especially in the proximal half of the spine; the profile of the lower surface is straight or slightly concave.

Sac spines of the type here described are guide fossils for certain Des Moines horizons, being known only from the upper middle Cherokee shale and equivalent beds to the south.

Occurrence.—Cap rock of Mineral coal, about 140 feet below top of Cherokee shale, Des Moines series, Pennsylvanian (Upper Carboniferous); sec. 25, T. 30 S., R. 24 E., about two miles west of Pittsburg, Kans. A. M. Brooks, collector.

Types.—Holotype, Kansas Univ. no. 0–60466; paratypes, nos. 0–60466a-c.

GISACANTHOSTEGA ANGUSTA Moore

Plate IV, figures 5a, b

Incomplete specimens of a long but very narrow type of anal sac spine are described under this designation. They are distinguished by the nearly parallel suture faces at the sides of the spine near the base and the similarly nearly parallel sides of the thin distal portion. Also noteworthy is the furrow that extends along the upper side longitudinaly; in some specimens this furrow reaches proximally to the base of the spine, but in others, including the holotype, it does not extend onto the area that is bordered by suture faces. Another peculiarity is the extension of the lower surface in a proximal direction as far as the upper surface. The spine curves downward very slightly.

Measurements of a typical example, selected as the holotype, are as follows: length (incomplete), 19.3 mm.; greatest width, 6.0 mm.; width near proximal end, 3.5 mm.; vertical distance from upper to lower surface near base, 3.8 mm.; width at broken distal extremity, 3.7 mm.; vertical distance through spine at distal end, 0.6 mm.

Occurrence.—Hickory Creek shale member, Plattsburg lime-

stone, Lansing group, Missouri series, Pennsylvanian (Upper Carboniferous); brick pit at Sycamore, Montgomery County, Kans. R. C. Moore, collector.

Types.—Holotype, Kansas Univ. no. 0–60052; paratypes, nos. 0–60052a-c.

Division CRINOPTERA Moore (Pinnates)

Segments of the free arms of crinoids, including all branches and the minute ones called pinnules, are here classed as Pinnates. The designation is synonymous with brachials and pinnulars, except that brachials of camerate crinoids belonging to the dorsal cup are excluded. The name of the division is derived from the Greek *krinon*—lily (crinoid) and *pteron*—feather; other roots used in names for assemblages of pinnates are *akanthos*—spine, *arthron*—joint, *dis*—two, *koinos*—ordinary, *sphen*—wedge, *tetragonon*—quadrangle, and *trapeza*—table.

Morphologic Characters.—Pinnates are distinguished from facetals by the presence of two or more facets for articulation with adjoining ossicles. There is normally a surface of articulation on the lower or proximal edge of the segment and another roughly parallel to it on the upper or distal edge. Axillary pinnates support two branches and these have three facets, one below and two two above. In addition, there may be small articular areas for connection with pinnules, ordinarily only one to a pinnate ossicle, but in cases of hyperpinnulation more than one. The articular facets are essentially plane surfaces in some crinoid arms, possibly marked by fine ligament denticles, but in types with full muscular development there are pits and ridges that are comparable to those on the radial facets. Many of the flexible crinoids have arm segments with a curved projection at the margin of the lower facet that slightly overlaps the adjoining segment; this projection is termed the patelloid process; ridges, pits, and fine denticles occur on the articular facets of flexible crinoids. (See Figure 13.)

The outer or dorsal surface of pinnates is commonly rounded but may be flat or ridged; this part of the plate is variously ornamented in many cases. The sides of these ossicles may also

be rounded and confluent with the dorsal surface, or flattened and and separated from the dorsal surface by a sharp angulation. In some cases there are interlocking structures of different sorts on the sides of arm plates, so that close connection is made with

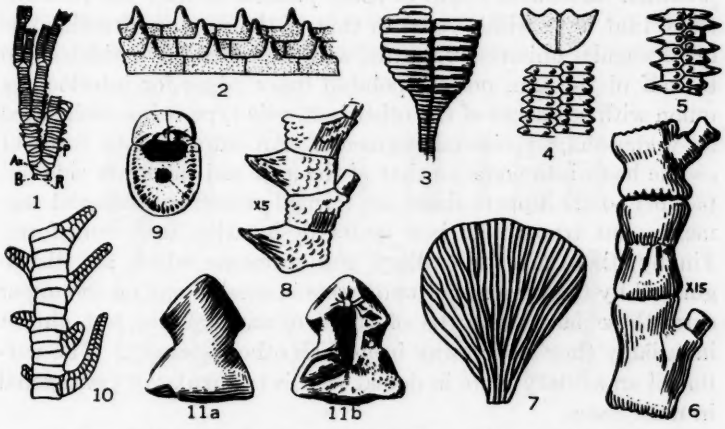


FIG. 13. MORPHOLOGIC FEATURES OF EXAMPLES OF PINNATES

1, Arms belonging to one ray of *Isocrinus; 2*, spine-bearing pinnules of *Cactocrinus proboscidialis* (Mississippian); *3*, a biserial arm belonging to *Eretmocrinus pennibrachiatus* (Mississippian), distinguished by the strong widening in distal region; *4*, cross-section and exterior view of a portion of the arm of *Eretmocrinus ramulosus* (Mississippian); *5*, portion of the arm of *Cactocrinus denticulatus* (Mississippian); *6*, portion of the arm of *Cyttarocrinus eriensis* (Devonian), the middle ossicle consisting of a syzygal pair; *7*, arm of *Petalocrinus inferior* (Silurian), a solid plate with ambulacral grooves on upper surface; *8*, arm segments of *Decadocrinus multinodus* (Devonian); *9*, view of the articular surface of an arm plate and ossicles covering the food groove belonging to *Cyathocrinus multibrachiatus* (Lower Carboniferous), also showing the opening for the dorsal canal; *10*, branch of the calyx (uniserial plates) bearing biserial arms, *Eucladocrinus millebrachiatus* (Mississippian); *11*, axillary pinnate belonging to an unknown crinoid, Permian of Timor. (After Bather, *1*, *9*; after Wachsmuth and Springer, *2–5*, *10*, *11*; after Goldring, *6*, *8*; after Springer, *7*).

segments of adjacent arms. The inner or ventral side of pinnates is grooved for reception of the food canal, or in the case of an arm made up of an interwedged double series of ossicles, the side toward the interior of the arm is beveled to form part of the

groove. A longitudinal perforation, the dorsal canal, is found in some crinoid pinnates; this lies beneath the food groove.

The shape of pinnates in cross-section of the arms has been noted, but not the outline as seen from the dorsal side. The proximal and distal edges of some pinnate ossicles are parallel; those that have width equal to that of the arm are described as quadrangular uniserial segments, and those that have width equal to half of the arm possess pointed inner edges for interlocking union with segments of the other half, this type being designated as wedge-shaped biserial segments. An intermediate form of ossicle has width equal to that of the arm and the lower side not parallel to the upper; these are termed cuneiform uniserial segments, but trapezoidal is a better designation than cuneiform. Finally, there are the axillary arm segments, which are distinguished by the presence of two facets instead of one on the upper side; these facets may be of equal or unequal size, but almost invariably they slope away from each other laterally. The outline of an axillary plate in dorsal view is triangular or pentagonal in most cases.

Classification of Pinnates.—It seems logical to distinguish arm segments primarily on the basis of form, separating quadrangular uniserial from biserial segments, and trapezoidal from quadrangular segments; also, axillary plates can readily be distinguished from others. Pinnulars, which might be established as a separate division if deemed important, can ordinarily be separated from small brachials. Ornamentation of the outer surface may be useful in differentiation of named forms, but there is an important difficulty in the fact that decoration of the lower part of an arm may not appear at all on the upper part. Largest problem is that of classificatory designation that will provide for isolated pinnate ossicles and at the same time embrace combinations of these as represented in an arm fragment. Three or more categories of arm segments, if classed on the basis of form of ossicle, might be found in a single arm. Pinnates that are associated in arm fragments and those that are dissociated are both found commonly. The former are not necessarily more useful

than the latter. We are driven to the conclusion that if pinnates are to be incorporated in the plan of designation used for other crinoid parts, it must be done on the basis of considering individual sorts of pinnates as the essential classificatory units. It will then be necessary to indicate an arm or fragment of arm consisting of different sorts of ossicles by combining the designations for the units that appear in the arm. Various com-

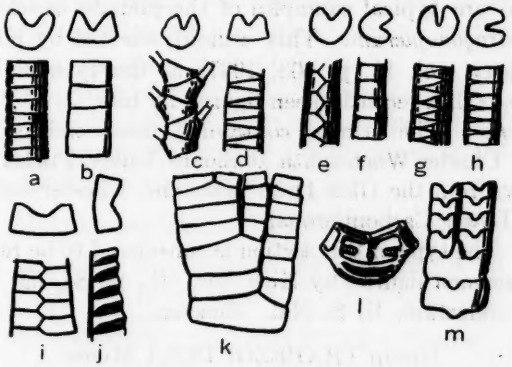


FIG. 14. DIAGRAMS SHOWING ARM STRUCTURES OF CRINOIDS

a, Round uniserial arm with quadrangular segments; *b*, arm of similar structure that is flat dorsally; *c*, trapezoidal uniserial segments with rounded cross-section, such as appears in *Decadocrinus; d*, an arm with wide, short trapezoidal segments, flat dorsally; *e*, a rounded biserial arm; *f*, same in side view; *g*, another type of round biserial arm; *h*, same in side view; *i*, a wide, dorsally flat biserial arm; *j*, same in side view; *k*, uniserial arms of a ray that branches heterotomously, the upper facets of axillary segments being unequal; *l*, articular surface of an arm segment of a flexible crinoid (*Forbesiocrinus*); *m*, portion of the arms of a flexible crinoid, showing the "patelloid" projections at midline of the sutures.

plications that conceivably may be met in proceeding with this course are wisely omitted from discussion until they are actually encountered. (See Figure 14.)

Main Group DIARTHROPTERA Moore

Pinnates that bear only two articular surfaces, one on the proximal side and one on the distal, small facets for attachment of pinnules not being considered.

Group TETRAGONOPTERA Moore

Diarthroptera that occupy the full width of the arm and have subparallel lower and upper articular surfaces. Group-type, *Tetragonopterum formosum* (Worthen).

TETRAGONOPTERUM FORMOSUM (Worthen), new comb.

The secundibrach segments in the arms of *Phanocrinus formosus* (Worthen) are typical examples of the pinnate ossicles belonging to *Tetragonopterum*. This crinoid, selected by Kirk (Jour. Paleontology, vol. 11, p. 603, 1937) as the type of his genus *Phanocrinus*, has recently been figured by him.

Occurrence.—The crinoid containing these ossicles was collected by Charles Wachsmuth at Sloans Valley, Pulaski County, Kentucky, from the Glen Dean limestone, Chester series, Mississippian (Lower Carboniferous).

Type.—The type of this section is considered to be represented in the specimen figured by Kirk (loc. cit., pl. 84, fig. 1), in the Springer collection, U. S. Nat. Museum.

Group TRAPEZOPTERA Moore

Diarthroptera that occupy the full width of the arm and have distinctly divergent lower and upper articular surfaces. Group-type, *Trapezopterum scalare* (Meek and Worthen).

TRAPEZOPTERUM SCALARE (Meek and Worthen), new comb.

Under this name are designated the secundibrach ossicles shown in the crinoid *Decadocrinus scalaris* (Meek and Worthen), figured in reports of the Illinois Geological Survey (vol. 5, p. 421, pl. 2, fig. 10).

Occurrence.—Upper Burlington limestone, Osage group, Mississippian (Lower Carboniferous); Burlington, Iowa.

Type.—The type of this section of pinnates is designated as represented in the type of Meek and Worthen's species.

Group SPHENARTHROPTERA Moore

Diarthroptera that occupy only one-half of the width of the arm, lower and upper articular surfaces parallel, pointed

on the side at the center of the arm for interlocking with similar segments; structure of the arm biserial. Group-type, *Sphenarthropterum monticulatum* (Beede).

SPHENARTHROPTERUM MONTICULATUM (Beede), new comb.

The ossicles of the unbranched portion of the arms of *Ethelocrinus monticulatus* (Beede) are designated under this name. The appearance of the segments is accurately shown by Beede (Kansas Univ. Geol. Survey, vol. 6, pl. 7, fig. 2).

Occurrence.—Howard limestone, Wabaunsee group, Virgil series, Pennsylvanian (Upper Carboniferous); near Topkea, Kans.

Type.—The type of this section is represented in the holotype of Beede's species, Kansas Univ. no. 3567.

Main Group TRIARTHROPTERA Moore

Axillary pinnates, characterized by presence of an articular facet below and two facets above.

Group COENARTHROPTERA Moore

Axillary pinnates that are gently rounded or nearly flat on the dorsal side, not produced in a spine. Group-type, *Coenarthropterum elegante* (Hall).

COENARTHROPTERUM ELEGANTE (Hall), new comb.

The axillary brachials shown in specimens of the crinoid *Eratocrinus elegans* (Hall) are here designated.

Occurrence.—Upper Burlington limestone, Osage group, Mississippian (Lower Carboniferous); Burlington, Iowa.

Type.—Examples shown in the specimen figured by Springer (U. S. Nat. Museum, Proc. vol. 67, pl. 21, fig. 2, 1926) may be taken as types of this section.

COENARTHROPTERUM CORRUGATUM Moore, new section

Plate IV, figures 2a-c

Axillary plates of relatively large size that occur with numerous ossicles classed as *Macrocrinarthrum corrugatum* and *Schedaglao-*

polygonum corrugatum are matched with these so as to warrant use of the section name here given. Clearly, they belong to an undescribed crinoid that might be reconstructed from dissociated plates, but this has not been done; it is not easy to secure plates that are of the proper size to fit together satisfactorily, and in the present instance there is doubt concerning possibility of establishing critical features of the posterior interradius. It is desirable to describe the individual types of ossicles separately.

The widest part of the axillaries coincides with the location of the transverse ridge of the large facet, which is the one for articulation with a subjacent radial plate. All of the basal area of the plate (the side directed inward when the plate is in natural position) is occupied by the large facet, which resembles in every detail the facet of the adjoining radial (here classed as a facetal); the transverse ridge is prominent, the outer ligament area well defined, containing a deep ligament pit, and the central pit, intermuscular furrow, intermuscular notch, and faintly grooved muscle areas are all well shown. The two facets of the upper side of the ossicle are triangular in outline; they are juxtaposed to form a large triangle, a sharp narrow ridge dividing the two facets and forming the vertical axis of the large triangle. Features of the large facet are duplicated on smaller scale in the upper facets. The outer surface of the plate is like a stretched cloth that connects the borders of the three facets, the shape of the surface being dependent essentially on the positions of the facet borders. There are slight but distinct corrugations arranged with transverse trend across the plate, and there is a tendency to develop a row of low nodes across the midlength of the plate.

Measurements of a typical specimen, designated as holotype, are as follows: greatest width, 21.0 mm.; length (measured from middle of transverse ridge of large facet to outer point of large triangle above), 8.5 mm.; length of large facet, 10.3 mm.; length of facet area at top of plate (measured from outer tip of triangle to innermost part of facets), 10.0 mm.

Occurrence.—Checkerboard? limestone, near base of Coffeyville shale, Ochelata group, Missouri series, Pennsylvanian (Upper Carboniferous); old brick pit in northwest part of Coffeyville, Kans. R. C. Moore collector.

Types.—Holotype, Kansas Univ. no. 0–46076; paratypes, nos. 0–46076a-d.

Group ACANTHARTHROPTERA Moore

Axillary pinnates that are produced dorsally in a distinct knob or spine. Group-type, *Acantharthropterum acutum* Moore.

ACANTHARTHROPTERUM ACUTUM Moore

Plate III, figures 5a, b

This includes robust, very sharp-pointed spined axillaries. The articular surfaces meet at the base of the plate in a right angle, that for articulation with the subjacent ossicle, which with little doubt is a radial plate, being vertical when the facets for union with the arm branches above are held horizontally. The outline of the base of the spine, which is that occupied by the lower facet, appears rectangular, but the inner margins of facet curve so that the upper corners of the rectangle are not included in the facet. The two facets on the upper surface of the plate are each triangular in outline, and together they form a larger triangle, the midline of which is marked by a strong ridge dividing the facets. The apex of the large triangle reaches about halfway from the base of the spine to its tip. In view from above or below the sides converge sharply outward from the base to a point about opposite the end of the facetted area and then are more nearly parallel toward the sharp point of the spine. In side view, with the upper facets held horizontally, the profile of the upper surface of the spine is horizontal except near the edge of the facet, from which it slopes downward; the profile of the lower surface bends strongly downward from the base of the spine to a low point under the middle of the upper facets, and then curves evenly upward to the point. Surface smooth.

Measurements of the holotype are as follows: length, 22.0 mm.; width, 15.0 mm.; height, 9.5 mm.; length of lower facet, 5.4 mm.; length of ridge dividing the upper facets, 10.0 mm.

Occurrence.—Cap rock of the Mineral coal, about 140 feet below the top of the Cherokee shale, Des Moines series, Pennsylvanian (Upper Carboniferous); sec. 25, T. 30 S., R. 24 E., about two miles west of Pittsburg, Kans. G. B. Brooks, collector.

Types.—Holotype, Kansas Univ. no. 0–60467; paratypes, nos. 0–60467a-d.

ACANTHARTHROPTERUM CORNU Moore

Plate IV, figures 3a, b

Another type of spined axillary may be described under this name. It is much smaller than that last treated. Similarity appears in the very sharp narrow spine, which extends about as far beyond the upper facets as the outward extent of these from the base. The lower facet, however, is strongly concave and the plane defined by its edges slopes outward and upward from the transverse ridge when the upper facets are held horizontally; the angle between the lower and upper facets is therefore obtuse. The outline in view from above or below follows the outer edge of the upper facets nearly to their end and then shows the narrowness of the round spine; viewed from the side with upper facets horizontal, the lower profile slopes evenly upward from the base of the spine to its tip. The surface is ornamented by closely spaced granules.

Measurements of the holotype follow: length, 14.5 m.; width, 10.2 mm.; height, 5.9 mm.; length of lower facet, 4.5 m.; length of ridge dividing upper facets, 7.5 mm.

Occurrence.—Cap rock of Mineral coal, about 140 feet below top of Cherokee shale, Des Moines series, Pennsylvanian (Upper Carboniferous); sec. 25, T. 30 S., R. 24 E., about two miles west of Pittsburg, Kans. G. B. Brooks, collector.

Type.—Holotype, Kansas Univ. no. 60469.

Main Group MICRARTHROPTERA Moore

Ossicles composing the fine branchlets of crinoid arms that are designated as pinnules.

Segments of pinnules are grooved on the ventral side and rounded on the dorsal side. They consist of uniserially arranged pieces that commonly are longer than their thickness. No detailed description or effort to subdivide pinnular ossicles is undertaken in this paper.

EXPLANATION OF PLATE I

PAGE

Cyclopentagonopa granulosa Moore 190

1, Holotype, Kansas Univ. no. 0-45321; *a*, view of articular face showing even crenellae, pentalobate lumen and granules near it, ×2; *b*, side view of columnal showing its smooth exterior, ×2. Sam Creek limestone, Savanna formation, Des Moines series, Pennsylvania; southwest of Porum, Okla.

Cyclopentagonopa excentrica Moore 191

2, Holotype, Kansas Univ. no. 0-60461; *a*, view of articular face showing off-center location of lumen and its surrounding crater, and long fine crenellae, ×2; *b*, side view of a pair of columnals that are apparently united by syzygy, ×2. Cap rock of Mineral coal, Cherokee shale, Des Moines series, Pennsylvanian; near Pittsburg, Kans.

Ellipsellipsopa spicata Moore 195

3, Holotype, Kansas Univ. no. 0-46079; *a*, view of articular surface of a nodal segment, the axis of the facet on the under side being inclined almost at right angles to that of the one in view, ×2; *b*, side view showing girdle of spines, ×2. Coffeyville shale, Missouri series, Pennsylvanian; Coffeyville, Kans.

Pentagonocyclopa dispar Moore 193

4, Paratype, Kansas Univ. no. 0-46071a; *a*, view of articular surface of a nodal, ×2; *b*, side view showing the elliptical facets of cirri, one of which occurs on each of the five sides, and an internodal segment below the nodal, ×4. Coffeyville shale, Missouri series, Pennsylvanian; Coffeyville, Kans.

5, Holotype, Kansas Univ. no. 0-46071; view of articular face showing crater around lumen and buttress-like projections within it, ×4. Same horizon and locality.

6, Paratype, Kansas Univ. no. 0-46071b; *a*, view of the articular face of an internodal, ×4; *b*, side view of stem fragment showing one nodal and several internodals, ×2. Same horizon and locality.

Ellipsellipsopa unnamed section 194

7, A stem fragment consisting of four columnals, ×2. Coffeyville shale, Missouri series, Pennsylvanian; Coffeyville, Kans.

Cyclocyclopa acuticarinata Moore 189

8, Holotype, Kansas Univ. no. 0-59271; *a*, view of articular face showing short crenellae and relatively large round lumen, ×2; *b*, side view of stem fragment showing internodals and two nodals, the latter being distinguished by cirri attachments located at side of keel, ×2. Stanton limestone, Missouri series, Pennsylvania; near Wayside, Kans.

Pentexobasis glypta Moore 208

9, Holotype, Kansas Univ. no. 0-60468; *a*, dorsal view of circlet showing ridged nature of distal part of plates, ×2; *b*, ventral view showing stelliform axial canal opening, ×2; *c*, side view showing fine denticles on suture faces, ×2. Cap rock of Mineral coal, Cherokee shale, Des Moines series, Pennsylvanian; near Pittsburg, Kans.

EXPLANATION OF PLATE I—*Continued*

PAGE

Pentanobasis regularis Moore 201

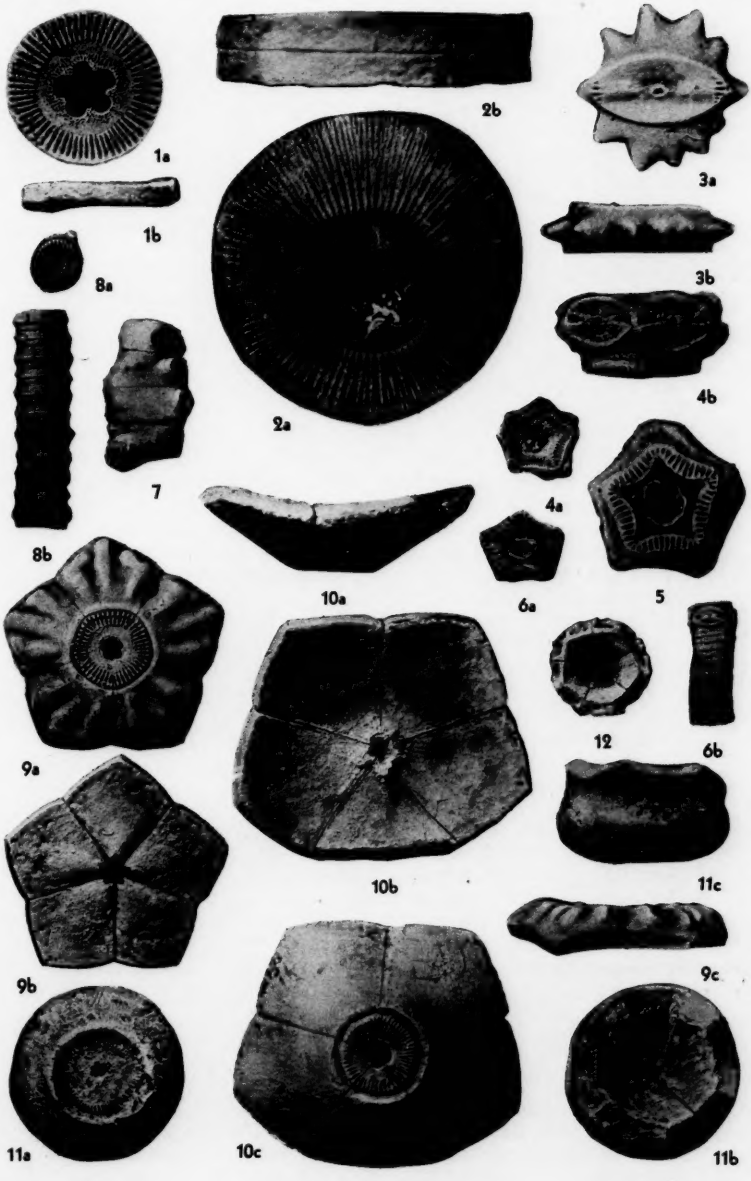
10, Holotype, Kansas Univ. no. 0-45511; *a*, side view showing upward flaring position of plates, ×2; *b*, ventral view, showing crater around canal opening, ×2; *c*, dorsal view, the stem area surrounded by a narrow depression, ×2. Stanton formation, Missouri series, Pennsylvanian; northwest edge of Bartlesville, Okla.

Isotrianobasis urna Moore 204

11, Holotype, Kansas Univ. no. 0-60471; *a*, dorsal view, ×2; *b*, ventral view showing the three subequal apicals, ×2; *c*, side view, ×2. Burlington limestone, Mississippian; Springfield, Mo.

Pentecatobasis excavata Moore 212

12, Holotype, Kansas Univ. no. 0-33061; dorsal view showing the strongly down-flaring attitude of the apicals and the pits in the distal suture faces, ×2. Wreford limestone, Big Blue series, Permian; northwest of Elmdale, Kans.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EXPLANATION OF PLATE II

PAGE

Triexobasis banioni Moore 210

1, Holotype, Kansas Univ. no. 0-59971; *a*, ventral view of apical circlet and two attached plates of the next circlet, showing three plates surrounding the triangular rim at the canal opening, ×2, *b*, dorsal view showing concave stem area and ornamentation of outer surface, ×2. Brownville limestone, Virgil series, Pennsylvanian; southwest of Strohm, Osage County, Okla.

Trianobasis bridwelli Moore 203

2, Holotype, Kansas Univ. no. 0-45701; *a*, dorsal view, ×2, *b*, side view, showing the nearly vertical attitude of the plates, two of the three apicals being partly shown, ×2. Oread limestone, Virgil series, Pennsylvanian; southwest of Lawrence, Kans.

Henanobasis coffeyvillensis Moore 206

3, Holotype, Kansas Univ. no. 0-46072; *a*, dorsal view of the fused apicals (infrabasals) showing the small round stem impression, ×2; *b*, ventral view, showing the facets for connection with plates of the next higher circlet, ×2; *c*, side view, indicating the slightly asymmetrical form and vertical sides near top, ×2. Coffeyville shale, Missouri series, Pennsylvanian; Coffeyville, Kans.

Hoplarthrum tenue Moore 221

4, Holotype, Kansas Univ. no. 0-60463; *a*, view of exterior from front, showing the narrow rounded facet, ×2; *b*, view from side showing profile, the sloping plane of the facet rim being indicated at the top, ×2; *c*, view of facet from above, showing shoulder-like extensions of the outer surface around the facet, ×2; *d*, view of inner side of plate, ×2. Cap rock of Mineral coal, Cherokee shale, Des Moines series, Pennsylvanian; near Pittsburg, Kans.

Engoniarthrum lineatum Moore 224

5, Paratype, Kansas Univ. no. 0-45891a; front view of a radial plate, ×4. Oologah limestone, Des Moines series, Pennsylvanian; Garnett quarry, northeast of Tulsa, Okla.

6, Holotype, Kansas Univ. no. 0-45891; front view, showing the narrow facet and the narrow diverging ridges on the non-articular surface, ×4. Same horizon and locality.

Hoplarthrum canalis Moore 220

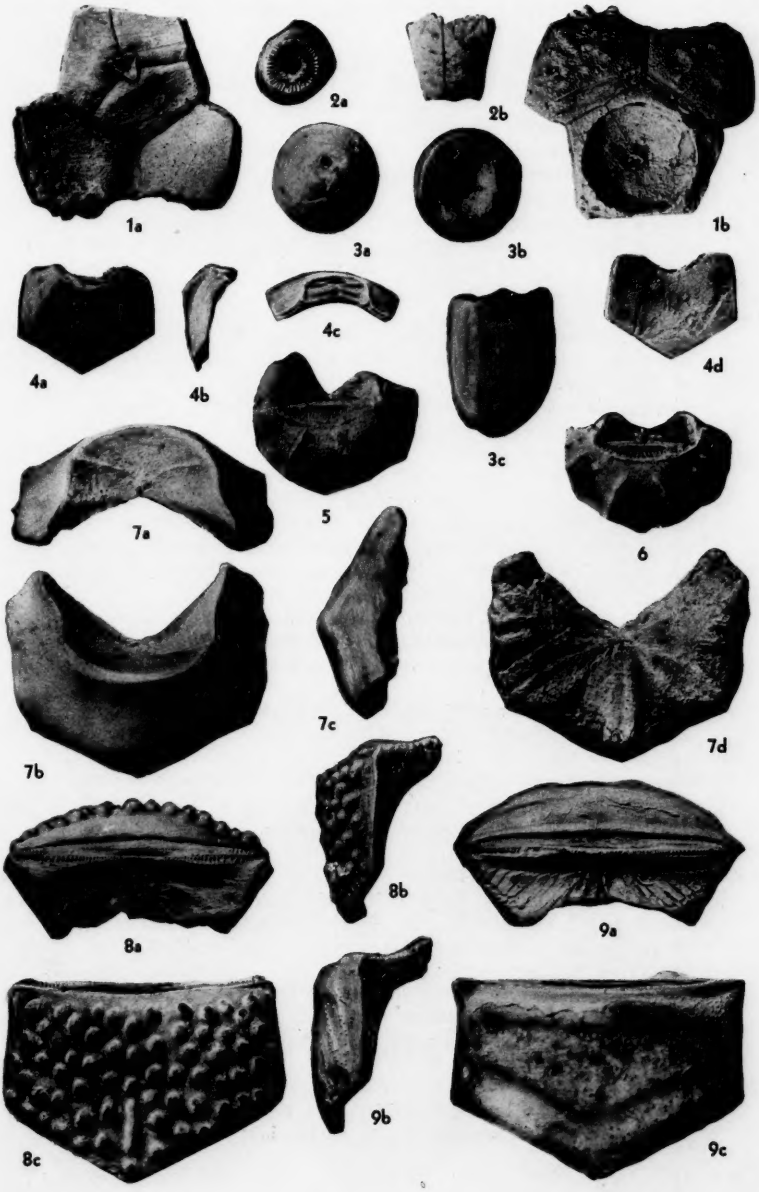
7, Holotype, Kansas Univ. no. 0-60462; *a*, view of plate from above showing rounded outline of narrow facet, ×2; *b*, front view, indicating the long inward extensions of the outer surface at sides of the facet, ×2; *c*, view of plate from side showing profile, ×2; *d*, interior view showing radially disposed thickenings of the plate, ×2. Cap rock of Mineral coal, Cherokee shale, Des Moines series, Pennsylvanian; near Pittsburg, Kans.

Macrocrinarthrum tuberculatum Moore 227

8, Holotype, Kansas Univ. no. 0-60464; *a*, view showing facet, ×2; *b*, side view showing shelflike inward projection of the facet, ×2; *c*, front view showing the prominent tubercles, ×2. Cap rock of Mineral coal, Cherokee shale, Des Moines series, Pennsylvanian; near Pittsburg, Kans.

Macrocrinarthrum corrugatum Moore 225

9, Holotype, Kansas Unov. no. 0-46074; *a*, view of facet showing the short and shallow outer ligament area, and well marked lateral furrows of the inner ligament area, ×2; *b*, side view, ×2; *c*, front view showing surface markings, ×2. Coffeyville shale, Missouri series, Pennsylvanian; Coffeyville, Kans.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EXPLANATION OF PLATE III

PAGE

Bunarthrum septatum Moore 228

1, Holotype, Kansas Univ. no. 0-60181; *a*, front view, ×2; *b*, side view, showing the strongly convex outer surface and septa of the interior, ×2; *c*, view of inner side showing the strongly elevated radiating walls, ×2; *d*, view of facet, ×2. Stanton limestone, Missouri series, Pennsylvanian; near Wayside, Kans.

Engoniarthrum granulosum Moore 222

2, Holotype, Kansas Univ. no. 0-60051; *a*, front view showing narrow sloping facet and arcuate transverse ridge below facet, ×2; *b*, side view, ×2; *c*, view of facet, ×4. Plattsburg limestone, Missouri series, Pennsylvanian; Sycamore, Kans.

Engoniarthrum lineatum Moore 224

3, Paratype, Kansas Univ. no. 0-45891a; front view, ×2. Oologah limestone, Des Moines series, Pennsylvanian; Garnett quarry, northeast of Tulsa, Okla.

4, Holotype, Kansas Univ. no. 0-45891; *a*, front view, ×2; *b*, side view, ×4. Same horizon and locality.

Acantharthropterum acutum Moore 249

5, Holotype, Kansas Univ. no. 0-60467; *a*, top view showing the triangular area of the two upper facets, ×2; *b*, side view showing the angle of the basal facet to the upper articular surfaces and the profile of the spine, which is a primibrach, ×2. Cap rock of Mineral coal, Cherokee shale, Des Moines series, Pennsylvanian; near Pittsburg, Kans.

Lophaglaopolygonum tenuirugosum Moore 234

6, Holotype, Univ. Iowa no. 3424; *a*, top view, ×2; *b*, front view showing surface ornamentation, ×2; *c*, side view showing curvature and thickness along suture faces, ×2. Missouri series, Pennsylvanian; southwestern Iowa.

7, Paratype, Univ Iowa no. 3424a; *a*, front view, ×2; *b*, top view, ×2; *c*, side view, ×2. Same horizon and locality.

Bunaglaopolygonum tuberculatum Moore 235

8, Holotype, Kansas Univ. no. 0-60464; *a*, front view showing surface ornamentation, ×2; *b*, top view, ×2. Cap rock of Mineral coal, Cherokee shale, Des Moines series, Pennsylvanian; near Pittsburg, Kans.

Schedaglaopolygonum corrugatum Moore 233

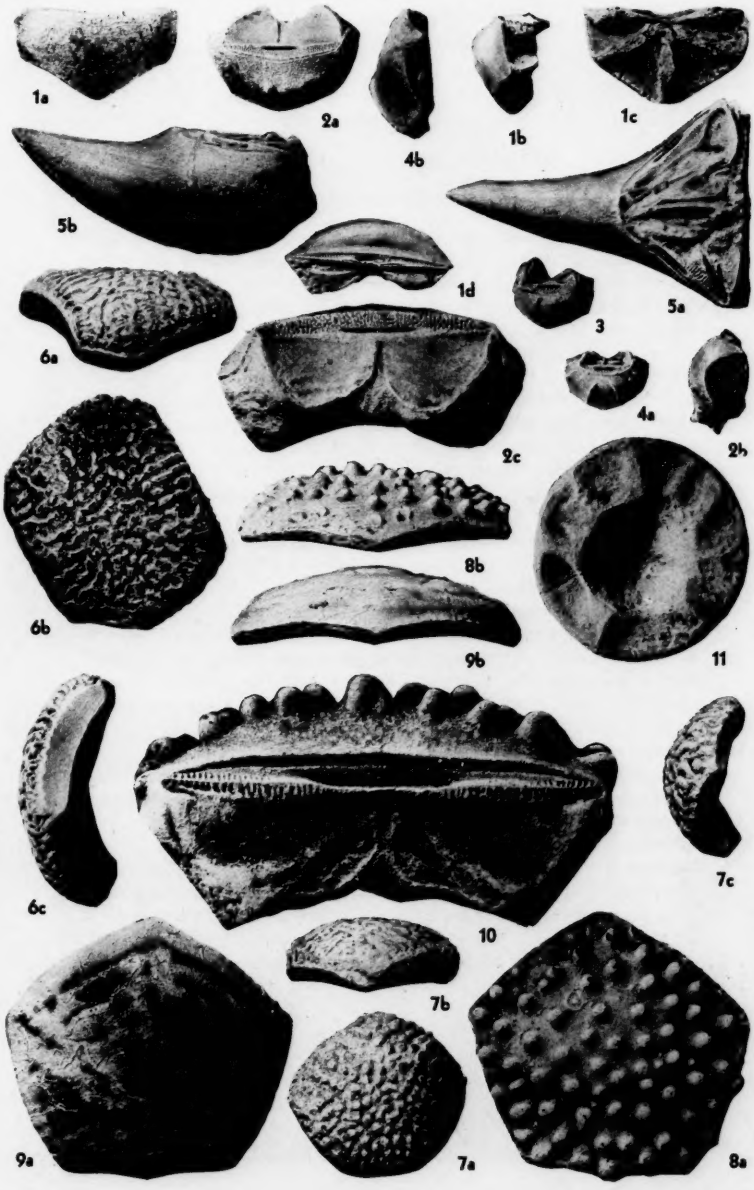
9, Holotype, Kansas Univ. no. 0-46074; *a*, front view showing surface features, ×2; *b*, top view, ×2. Coffeyville shale, Missouri series, Pennsylvanian; Coffeyville, Kans.

Macrocrinarthrum tuberculatum Moore 227

10, Paratype, Kansas Univ. no. 0-60464a; view of facet enlarged to show transverse ridge and ligament areas, ×5. Cap rock of Mineral coal, Cherokee shale, des Moines series, Pennsylvanian; near Pittsburg, Kans.

Henanobasis coffeyvillensis Moore 206

11, Holotype, Kansas Univ. no. 0-46072; ventral view showing facets, ×4. Coffeyville shale, Missouri series, Pennsylvanian; Coffeyville, Kans.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EXPLANATION OF PLATE IV

PAGE

Pentezobasis plana Moore 209

1, Holotype, Kansas Univ. no. 0-46073; *a*, dorsal view, ×2; *b*, ventral view, showing stellate rim around canal opening, ×2; *c*, side view, ×2; *d*, enlarged view of distal suture faces showing bundles of irregular denticles. Coffeyville shale, Missouri series, Pennsylvanian; Coffeyville, Kans.

Coenarthropterum corrugatum Moore 247

2, Holotype, Kansas Univ. no. 0-46076; *a*, front view, ×2; *b*, top view showing articular facets, ×2; *c*, bottom view showing surface markings, ×2. Coffeyville shale, Missouri series, Pennsylvanian; Coffeyville, Kans.

Acantharthropterum cornu Moore 250

3, Holotype, Kansas Univ. no. 0-60469; *a*, bottom view showing form and surface markings, ×2; *b*, top view, ×2. Cap rock of Mineral coal, Cherokee shale, Des Moines series, Pennsylvanian; near Pittsburg, Kans.

Gisacanthostega expansa Moore 240

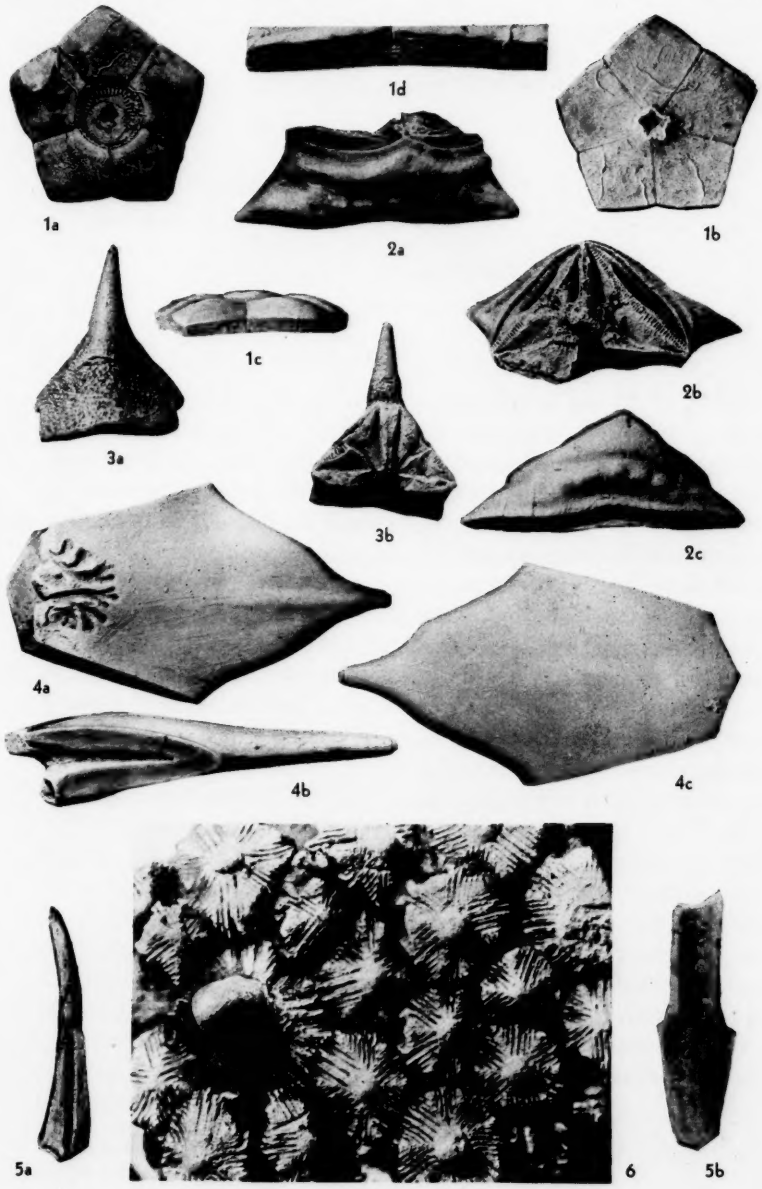
4, Holotype, Kansas Univ. no. 0-60466; *a*, under side view of anal sac spine, showing grooves near base and midrib near tip of spine, ×2; *b*, side view showing groove dividing upper and lower parts of suture face at base of spine, ×2; *c*, top of spine, ×2. Cap rock of Mineral coal, Cherokee shale, Des Moines series, Pennsylvanian; near Pittsburg, Kans.

Gisacanthostega angusta Moore 241

5, Holotype, Kansas Univ. no. 0-60052; *a*, side view, ×2; *b*, top view, the distal part of spine broken, ×2. Plattsburg limestone, Missouri series; Pennsylvanian; Sycamore, Kans.

Aulosomphostega incisa Moore 238

6, Holotype, U. S. Nat. Museum no. 147334; anal sac plates with deeply slit respiratory markings, the central part of the plates bearing node-like protuberances, and one plate that possibly marks the summit of the sac bearing a larger spine, ×3.7. Cap rock of Mineral coal, Cherokee shale, Des Moines series, Pennsylvanian; near Pittsburg, Kans.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NEW OSTRACODES FROM THE GOLCONDA FORMATION[1]

CAREY CRONEIS AND ARTHUR S. GALE, JR.

Received November 1, 1938; published January 14, 1939

INTRODUCTION

A number of years ago, at the suggestion of Dr. M. M. Leighton, the senior author of the series of papers appearing in this number of the JOURNAL undertook the micropaleontologic study of the samples of Chester (late Mississippian) sediments in the collection of the Illinois State Geological Survey. The samples proved almost embarrassingly rich in micropaleontologic remains, some of which represent groups either entirely new or at best little understood. For this, and a number of other reasons, the work has progressed slowly, and is at present far from completed. Recent drilling activity in the Illinois oil basin, however, has made it imperative that at least progress reports be published on the studies of the ostracodes. This is especially true since the fossils of this group can be employed in subsurface correlation of the sediments most commonly penetrated in the search for oil.

This paper and the following two articles [Croneis and Funkhouser (1938), Croneis and Thurman (1938)], therefore, will serve to indicate merely a number of the new species of ostracodes to be expected in three, of the at least eight, ostracode bearing formations of the Chester series. No attempt is made here to describe the complete ostracode faunas, nor is it practical at this time to try to give the complete geological ranges for the species which are described. In short, these papers are intended only to provide the bases for future specific comparisons, and the points of departure for further researches.

[1] Published with the permission of Dr. M. M. Leighton, Chief, Illinois Geological Survey.

ACKNOWLEDGMENTS

The material yielding the ostracodes described in this paper was obtained from outcrops of the Golconda formation in southern Illinois. Most of the collecting was done by Mr. L. E. Workman and Mr. J. E. Lamar of the Illinois Geological Survey, or by members of that organization under their direct supervision. Some of the ostracodes had also been sorted out and studied in a preliminary way by Mr. J. E. Lamar before the samples were sent to Walker Museum. To both of these men and their staffs, and especially to Dr. M. M. Leighton, who foresaw the importance of these studies long before they became so economically significant, we are pleased to acknowledge our indebtedness. We are also under obligations to a long list of mostly anonymous, but by no means forgotten, graduate students whose sample preparation and preliminary sorting of the fossils have greatly facilitated all of these researches. With real danger of injustice to some not specifically named we feel impelled to cite in this connection Dr. Harold Scott, R. V. Hollingsworth, H. L. Geis and C. L. Cooper, the latter of whom has continued to be of aid since becoming a member of the Illinois Geological Survey. Finally, we are indebted to Mr. Michael S. Chappers for photographic assistance.

THE GOLCONDA FORMATION

The Golconda formation occurs considerably below the middle of the Upper Mississippian Chester series, as is shown in the accompanying table of Illinois Chester formations.

Kinkaid limestone and shale
Degonia sandstone
Clore limestone and shale
Palestine sandstone
Menard limestone and shale
Waltersburg sandstone
Vienna limestone and shale
Tar Springs sandstone
Glen Dean limestone and shale
Hardinsburg sandstone
GOLCONDA limestone and shale

Cypress sandstone
Paint Creek limestone and shale
Bethel sandstone
Renault limestone and shale
Aux Vases sandstone

The formation is named from its excellent exposures in the bluffs of Lusk Creek and the Ohio River just north of Golconda in Pope County, Illinois. The Golconda [Stuart Weller (1920)] is essentially a succession of limestone and shale beds, with the limestone predominant particularly near the base. The individual limestone layers vary somewhat in character, but are commonly crystalline, and gray or bluish in color. The lower limestone beds are masses of fossil fragments which weather to a rough surface. More or less sandy shale beds grading into sporadic local sandstones are encountered at some places.

The maximum thickness of the formation is difficult to determine accurately because of its loess blanket and talus covered contacts, but probably it is close to 150 feet. In Illinois the Golconda is underlain by the Cypress sandstone, but in Missouri the Cypress is wanting and the Golconda rests on the Paint Creek formation, although, so far as we know, the exact contact is nowhere visible.

In Illinois there is a gradation from the Cypress into the Golconda, but there is apparently a disconformity between the Paint Creek and Golconda in Missouri. The Hardinsburg sandstone overlies the Golconda disconformably in most places; yet in others there is a suggestion of gradational sequence between these formations. The lower Okaw of the Mississippi Valley has been considered the correlative of the Golconda because of the megascopic faunal similarities of these formations. According to Stuart Weller (1928) the crinoid *Pterotocrinus capitalis* is the best index fossil in the rich megascopic fauna of the Golconda.

GOLCONDA OSTRACODES

Since the literature on ostracodes of Chester age is meager, it is at present impossible to correlate the Golconda formation exactly with other widely separated Chester beds on the basis

of its ostracode fauna, although we hope that this paper will serve as a basis for later correlations. Morey (1935), however, has described an ostracode fauna from the Amsden formation of Wyoming which includes several species closely related to forms occurring in the Golconda limestone. Based on it sostracode fauna the Amsden formation was regarded with some uncertainty as being older than the Chester and probably of Ste. Genevieve age. Considered in the light of the Golconda fauna, however, it may be suggested that the Amsden is of Chester age, but it may be more closely related to some other part of the Chester than the Golconda. Further work on all the Chester ostracode faunas is necessary before a more definite statement can be made.

The primary types of the new species of ostracodes described in this paper are deposited in Walker Museum, University of Chicago. Comparative material will be placed on file at the Illinois Geological Survey.

LABORATORY PROCEDURE

After considerable experimentation it was found that ostracodes were most abundant in the weathered shaly limestones of the Golconda. Trial and error methods then showed it convenient to boil a portion of each sample in a weak solution of sodium hydroxide. The time of treatment varied from twenty minutes to three hours depending on how readily the sample broke down. Next the material was washed to remove as much of the argillaceous fraction as possible, and then the sample was dried and screened into six grade sizes. The screened fractions were then placed on ruled sorting trays and examined under a binocular microscope. A second portion of each original sample was digested in very dilute hydrochloric acid in an effort to recover any arenaceous fossils.

The ostracodes were most numerous on the sixty mesh screen, and the eighty mesh yielded more in general than did the forty mesh size. Ostracodes in the pan and on the 100 mesh were rare or fragmental; only a few were large enough to be caught on the 20 mesh. Of the many samples examined only a few yielded

abundant or diversified ostracode faunas. It seems likely, therefore, that only a fraction of the species described in this paper will be found in any one well sample from the Golconda horizon.

Some of the photography was done with a Leica camera mounted on a Spencer binocular microscope, some with the same camera and the Leitz Ultropaque equipment.[2] The details of the specimens were brought out by whitening with ammonium chloride. The method described by Cooper (1935) proved to be more successful than the method described by Bassler and Kellett (1934) in that, in employing the former procedure, the grain size of the ammonium chloride film was diminished and the danger of harming the specimens with acid fumes was at least reduced.

SYSTEMATIC DESCRIPTIONS

Class CRUSTACEA
Superorder OSTRACODA Latreille
Family Leperditiidae Jones
Genus LEPERDITIA Rouault
Leperditia juvenis Croneis and Gale, n. sp.

Plate V, fig. 20

Carapace small, subovate; hinge line straight; right valve overlaps left along ventral half of free margin. Anterior end rounds sharply forward from cardinal angle to long, rather steep, backward swing; posterior end broadly and subuniformly rounded from cardinal angle to junction with anterio-ventral swing. A tubercle lies dorso-centrally in anterio-dorsal quarter. Broad posterior border commences somewhat below dorsum runs to junction of posterio-ventral and anterio-ventral swings, outlined by a sinus. Carapace rounds smoothly to high area slightly anterio-ventral to mid-point of carapace. Surface smooth.

Dimensions of type specimen: length, .42 mm.; height, .31 mm.; thickness, .17 mm.

[2] Although photographs are greatly to be preferred over drawings, no one as yet has discovered a really satisfactory method of photographing microscopic biconvex opaque objects.

Locality G2. Holotype, Walker Museum, No. 44400.

Remarks: There is a possibility that the posterior border of the specimen illustrated is slightly crushed. This genus has representatives showing but slight change over an extraordinarily long geologic range. Bassler and Kellett, however, give its latest appearance as early Devonian.

Family Leperditellidae U and B
Genus PARAPARCHITES U and B
Paraparchites inornatus (McCoy)

Plate VI, fig. 33

Cythere inornata McCoy, Syn. Char. Carb. Fossils, Ireland (1844), p. 167, pl. 23, fig. 18.

Paraparchites inornata Harlton, Jour. of Pal., Vol. 1 (1927), p. 203, pl. 32, figs. 1a, b.

Dimensions of figured specimen: length, 1.03 mm.; height, .77 mm.; thickness, .51 mm.

Locality G1. Hypotype, Walker Museum, No. 44401.

Remarks: The figured specimen of this ubiquitous ostracode is the largest of this species found in the Golconda limestone.

Genus MICROPARAPARCHITES Croneis and Gale, n. gen.

Carapace small, thick, subovate, hinge line straight. Cardinal angles obtuse, but not necessarily well defined. Right valve overlapping left at anterior cardinal angle. A globose swelling in dorso-posterior quarter rises above hinge line; swelling may be spine bearing.

Genotype: *Microparaparchites spinosus* Croneis and Gale, n. sp.

Remarks: Distinguished from *Paraparchites* by its much smaller size, right valve overlapping left at anterior angle, and by globose swelling in dorso-posterior quarter.

Microparaparchites spinosus Croneis and Gale, n. sp.

Plate VI, figs. 30–31

Carapace small, subovate in outline, the right valve overlapping the left strongly at the dorso-anterior angle; overlap not

apparent elsewhere. Anterior cardinal angle obtuse but distinct, posterior angle indefinite. Globose swelling lying nearly entirely in dorso-posterior quarter rises noticeable above hinge line with its greatest height, except for the spine, posterio-central in position. The spine rises from the dorso-posterior swollen area and lies above and slightly anterior to posterior cardinal angle. Some specimens show several rows of indistinct pits or small ridges around the spine base as seen in side view. The carapace is thickest at base of spine.

Dimensions of type specimen: length, .61 mm.; height, .43 mm.; thickness, .34 mm. at base of spine.

Locality G3. Holotype, Walker Museum, No. 44402.

Remarks: The two rounded pits on the type specimen are apparently breaks in the shell, as other individuals of the species do not possess them.

Family Primitiidae U and B, emend., Swartz
Genus PERPRIMITIA Croneis and Gale, n. gen.

Valves deeply sulcate, right valve overlaps left partially or entirely along free margin, conspicuously along venter. Posterior lobe may be spine bearing, separated from anterior lobe by narrow groove. Otherwise similar to *Primitia*.

Genotype: *Perprimitia robusta* Croneis and Gale, n. sp.

Perprimitia robusta Croneis and Gale, n. sp.

Plate V, fig. 23

Carapace suboblong to subovate, medium sized; hinge line straight, depressed. Right valve overlaps left ventrally and at ends. Prominent median sulcus, with ventral end pit-like, lies anterior to middle of carapace. Behind the pit the shell swells gently to an abrupt turret-like posterior which rises above hinge line. High point of this swollen area is about at mid-height of carapace in posterior-central area; the structure bears a spine near the cardinal angle. A swelling which rises from the anterior

cardinal angle region swings below and behind the pit and tends to encroach on the base of the posterior swelling in the area posterio-ventrad of pit where, however, a sinus separates the two swellings. Greatest height of carapace is through anterio-central region. Anterior end more broadly rounded than the posterior. In dorsal view the greatest thickness is definitely posterio-central in position. Surface essentially smooth.

Dimensions of type specimen: length, .67 mm.; height, .41 mm.; thickness, .34 mm.

Locality G1. Holotype, Walker Museum, No. 44403.

Remarks: The orientation of this species is based on the position of greatest thickness rather than on height or "backward" swing. This species is distinctive and it is not likely to be confused with any other late Paleozoic form except *P. spinosa.*

Perprimitia spinosa Croneis and Gale, n. sp.

Plate V, fig. 28

Carapace suboblong to subovate, medium sized; hinge line slightly concave; cardinal angles obtuse, indistinct; right valve the larger. Anterior outline uniformly and broadly rounded, swings abruptly into posterior outline; posterior outline nearly uniformly rounded, but more sharply so than anterior. Greatest height anterio-central; greatest thickness posterio-central. Prominent pit lies slightly dorsad to mid-point of carapace. A very shallow, ill-defined sulcus extends from pit toward hinge line. Behind the pit carapace swells into a turret-like elevation; anterior to pit carapace is also inflated but less prominently than posteriorly. Anterior swelling merges smoothly into centrally swollen area which, posterio-ventrad to pit, encroaches on, but is demarked by a narrow sinus from posterior swelling. A delicate, fairly long and sharply terminated spine rising from posterio-dorsal shoulder is directed backward and somewhat upward. A small node lies slightly anterior to pit. Surface essentially smooth.

Dimensions of type specimen: length, .65 mm.; height, .40 mm.; thickness, .21 mm. (single valve).

Locality G1. Holotype, Walker Museum, No. 44404.

Remarks: This species is closely related to the other Golconda representative of the genus. Although the similarities are striking, there appears to be enough variation to warrant the erection of a second species in this group. *P. spinosa* differs from *P. robusta* in that its spine is more prominent and projects at a lesser angle to carapace; its median sulcus is much less distinct; and unlike *P. robusta* it bears a small node anterior to pit.

Perprimitia ? bicornis Croneis and Gale, n. sp.

Plate V, fig. 24

Carapace small, subquadrate; hinge line slightly concave. Anterior cardinal angle obtuse, blunted; posterior angle approximately 90°, rather sharp. Anterior outline broadly rounded, sharpest curvature anterio-ventral in position, rounds abruptly into venter; posterior outline truncate joining venter at obtuse angle; venter rounded. Sub-prominent median sulcus lies slightly behind middle of carapace. Anterior to sulcus lies a double node, the smaller of the two prominences rising out of the anterio-ventral side of the larger. Prominent small spine lies close to hinge line at posterior cardinal angle. A broad swelling along venter below sulcus beginning along anterior end, rises posterior to a tubercle-like termination elevated about $\frac{1}{3}$ posterior shell height above venter. Area of greatest thickness posterio-central. Borderless except for submarginal rolled area in anterio-ventral position. Surface finely punctate.

Dimensions of type specimen: length, .31 mm.; height, .25 mm.; thickness, .12 mm. (single valve).

Locality G2. Holotype, Walker Museum, No. 44405.

Remarks: This species is only provisionally referred to Perprimitia. When more specimens are procured doubtless a new genus will have to be erected for ostracodes of this type.

Family Acronotellidae Swartz
Genus MONOCERATINA Roth
Monoceratina furcula Croneis and Gale, n. sp.

Plate V, figs. 21–22

Carapace small, elongate, suboblong; hinge line straight; cardinal angles obtuse, distinct. Essentially equi-valved. Thickness and height subequal. Posterior end rounds gently backward from cardinal angle, then turns abruptly forward into short posterio-ventral swing; anterior end subuniformly rounded. Flat posterior border demarked from elevated area of carapace by a sinus; much weaker but similar border and sinus occurs at anterior end. Carapace broadly rounded from dorsum, anterior and posterior borders to high area somewhat posterio-ventrad to mid-point of shell. A longitudinally elongate lobe originating ventrad to high area projects below venter, and is rather sharply terminated anteriorly. Ventral outline of lobe straight, merging into posterio-ventral swing; anteriorly lobe outline swings abruptly upward to rest of carapace about one quarter shell length from anterior end. In ventral view the two lobes of complete carapace assume a wishbone shape with open end anterior. Lobes extend laterally no farther than maximum thickness of rest of carapace. In lateral view the lobe is demarked by an offset in ventral outline, and by a sinus, strongest anteriorly. Entire surface finely and neatly reticulated.

Dimensions of type specimen: length, .56 mm.; height, .27 mm.; thickness, .28 mm.

Locality G3. Holotype, Walker Museum No. 44406.

Remarks: The ventral swelling of this species is less spine-like and smaller than the swelling of many other species of *Monoceratina*.

Genus PTEROCODELLA Croneis and Gale, n. gen.

Valves essentially equal, hinge line marked by a broad, shallow, V-shaped sag. Shell deeply sulcate beginning at the apex of the sag in hinge line, sulcus most prominent in dorsal half of cara-

pace, but may extend to venter. Shell expanded in venter where a row of cavities may border the margin.

Genotype: *Pterocodella mirablilis* Croneis and Gale, n. sp.

Remarks: There is some possibility that the cavities may represent broken brood pouches. This genus is so unusual that it cannot be assigned a position in a family with certainty. Its affinities, however, probably are with the Acronotellidae.

Pterocodella mirablilis Croneis and Gale, n. sp.

Plate V, figs. 25–27

Carapace medium sized, thicker than high; hinge line straight except for broad shallow V-shaped median sag, the apex of which is slightly behind the middle of hinge line. Cardinal angles obtuse, the posterior being the most distinct; valves essentially equal. A broad prominent median sulcus originating at the "V" of the hinge line swings posterio-ventrally then ventrally to the lower edge of shell. Anterio-ventrad of the sinus a high parallel swelling rises precipitously from it and falls away less steeply anterio-ventrally. A sharp, narrow sinus originating at the venter, lies close to, and nearly parallel to the anterio-ventral outline, dies out at about mid-height of carapace. Carapace thickens irregularly from the dorsum to the venter except in area anterior to the anterio-ventral sinus. Ventral outline somewhat scolloped. Rising from posterio-central area is a semi-conical shaped swelling whose line of truncation forms the posterio-ventral outline. A sinus flanks this structure posterio-dorsally.

In ventral view four, partially matrix filled, longitudinally arranged elliptical cavities border the inner margin of each valve. The posterior cavity forms the end of the semi-conical swelling at the posterio-ventral slope. Outline of middle pair of cavities roughly parallels the hinge line; anterior cavity borders the anterio-ventral sinus. Ventral contact of valves somewhat depressed in relation to outer flanges of cavities. In dorsal view complete shell resembles conventionalized outline of small winged, broad tailed, bird in flight.

Dimensions of type specimen: length, .77 mm.; height, .39 mm.; thickness, .45 mm.

Locality G1. Holotype, Walker Museum, No. 44407.

Remarks: Although the type specimen is the only complete carapace found, several fragmental valves in the collection have the same extraordinary characters shown in the illustrated specimen, and demonstrate that the species is a valid one.

Family Drepanellidae? Swartz

Genus GOLCONDELLA Croneis and Gale, n. gen.

Valves subequal, the right slightly larger than the left; hinge line straight; anterio-dorsal quarter depressed. Valves marked by extremely broad and deep median depression bordered ventrally by a prominent crescent shaped swelling.

Genotype: *Golcondella sulcata* Croneis and Gale, n. sp.

Golcondella sulcata Croneis and Gale, n. sp.

Plate V, fig. 30

Carapace small, subovate; hinge line straight; cardinal angles obtuse, anterior more obtuse than posterior, somewhat blunted. Right valve overlaps left slightly along venter, and possibly at ends. Very prominent, broad, median sulcus curves anterio-ventrally. An elongate, swollen crescent shaped lobe trending obliquely upward from anterio-ventral swing to near posterior cardinal angle outlines the sulcus ventrally, posteriorly, and to a lesser extent, anteriorly. Anterio-ventrally the swelling approaches nearest the shell outline, from which area it forks, and swings dorsally following outline of carapace until it dies out just above mid-height of shell. A conspicuous, deep, but narrow sinus outlines swelling posteriorly. A small ridge, paralleling the sinus, lies between the latter and the posterior margin. Anterio-dorsal quarter appears depressed in dorsal view.

Dimensions of type specimen: length, .62 mm.; height, .39 mm.; thickness, .20 mm.

Locality G1. Holotype, Walker Museum, No. 44408.

Remarks: Other individuals of this species, smaller, and apparently younger, than the illustrated specimen, fail to show the posterior sinus and ridge. The species is sufficiently distinctive that it is not likely to be confused with any other ostracode.

Family Aechminidae? Swartz
Genus LEIGHTONELLA Croneis and Gale, n. gen.

Hinge line straight; left valve overlaps right. Prominent sinus anterior to conspicuous spine. Possesses a border.

Genotype: *Leightonella torta* Croneis and Gale, n. sp.

Remarks: The spine of *Leightonella* may possess a backward curve, and it is more blade-like than in *Aechmina*.

Leightonella torta Croneis and Gale, n. sp.

Plate V, fig. 19

Carapace elongate, subsemicircular, medium sized, hinge line straight; slightly depressed. Cardinal angles nearly ninety degrees, posterior sharp, anterior blunted; valves subequal, right valve rabbeted to receive the left. Anterior end blunted, rounds smoothly into venter with long swing; posterior rounds with decreasing curvature from cardinal angle to venter; venter rounded. Prominent median sulcus slightly anterior to middle of carapace. Posterior to sulcus in posterio-dorsal quarter a subglobose swelling rises above hinge line; dorsally a prominent, rather broad, blade-like spine rises from swelling; spine curves backward and projects laterally at approximately 45° to plane between valves. Spine nearly half carapace height in length. Carapace rounds from spine bearing swelling and sulcus to submarginal groove and flange which extend from angle to angle. Surface finely punctate.

Dimensions of type specimen: length, .98 mm.; height, .48 mm. (to base of spine); thickness, .24 mm. (single valve).

Locality G3. Holotype, Walker Museum, No. 44409.

Remarks: Although this genus is represented by only one species and the latter by only one valve, it is of extraordinary

shape, well preserved, and shows clearly the hingement and overlap conditions. There is no chance of its being easily confused with any other known form. The genus is referred to the family Aechminidae. *Leightonella* may readily be distinguished from *Aechmina* by the lack of a sulcus in the latter; it may be distinguished from other horned Aechminidae by the location of its spine posterior to the sulcus.

Family Beyrichiidae Jones
Genus BEYRICHIA McCoy
Beyrichia placida Croneis and Gale, n. sp.

Plate V, fig. 31

Carapace subovate, medium sized; hinge line straight or very slightly convex. Right valve overlaps left anteriorly and centrally. Anterior cardinal angle obtuse, sharp; posterior angle obtuse, indistinct. Greatest height of carapace anterior to midpoint. Prominent median sulcus dorso-central in position between posterior and median nodes. Conspicuous, small, anterior sulcus separates the anterior and median nodes. A large elongate swelling rising from ventral margin swings dorsally somewhat more abruptly than ventral outline of carapace; swelling encroaches on the ventral base of the three nodes, and almost merges with the anterior and median ones. High point of swelling lies at anterior end of the posterio-ventral quarter.

Dimensions of type specimen: length, .66 mm.; height, .39 mm.; thickness, .30 mm.

Locality G2. Holotype, Walker Museum, No. 44410.

Remarks: There is some possibility that the prominent swelling may be a brood pouch. A small anterio-dorsal section of the left valve is broken from the type specimen illustrated. This species appears to be one of the simpler members of the genus *Beyrichia* to which it is referred with some doubt. It differs from the typical representatives of *Beyrichia* in the character and position of its lobes, and in possessing an extremely large and broad sulcus.

Family Kloedenellidae U and B
Genus JONESINA U and B
Jonesina persulcata Croneis and Gale, n. sp.

Plate VI, fig. 21

Carapace subovate, medium sized; hinge line straight. Left valve larger than the right slightly overlapping it ventrally and posteriorly. Cardinal angles distinct, obtuse, posterior angle the larger and somewhat blunted. A deep, rather broad, prominent sulcus lies somewhat posterior to middle of carapace. Posterior to the sulcus is a gently rounded, medium sized lobe; anterior to the sulcus lies a larger, expansive dome-like lobe bearing a small tubercle near the cardinal angle. Below the sulcus, and roughly paralleling the ventral outline lies a third swelling which forms the major lateral prominence of the shell; its high point is slightly below and anterior to mid-point of carapace. Surface essentially smooth.

Dimensions of type specimen: length, .66 mm.; height, .38 mm.; thickness, .35 mm.

Locality G1. Holotype, Walker Museum, No. 44411.

Remarks: This species resembles *J. bolliaformis* (Ulrich and Bassler), from the Cottonwood shales of Kansas, but the anterior lobe of the latter is smaller, more sharply defined, and lacks the tubercle present on *J. persulcata.* In addition the median sulcus of *J. persulcata* is deeper, and, being broader, is a more prominent feature of the shell.

Jonesina ? *dubia* Croneis and Gale, n. sp.

Plate V, fig. 29

Carapace subovate, medium sized; hinge line straight. Left valve overlaps the right completely, but not conspicuously in the posterior. Median sulcus broad, shallow, inconspicuous, lies dorsad and slightly anterior of mid-point of carapace. Greatest thickness and blunter end posterior, greatest height anterio-central. Cardinal angles obtuse, and blunted. Posterior ex-

tremity of carapace located at approximately one-third of shell height below hinge line; anterior extremity about one-third of height above venter. The swollen central area of carapace rounds gradually from the hinge line and posterio-dorsal slope, but rises abruptly from the venter and anterior end. Posterior and ventral portions of top of swelling somewhat flattened, or very broadly rounded.

Dimensions of type specimen: length, .72 mm.; height, .45 mm.; thickness, .38 mm.

Locality G1. Holotype, Walker Museum, No. 44412.

Remarks: The subcentral pit is less conspicuous on the actual specimen than on the photograph. The location of the median sulcus in the anterior half of the shell is not strictly typical of the genus *Jonesina*, to which this species is referred with some uncertainty.

Genus KNOXINA Coryell and Rogatz

Knoxina inflata Croneis and Gale, n. sp.

Plate VI, figs. 17–18

Carapace subsemicircular to subovate, medium sized; hinge line straight; cardinal angles obtuse, distinct. Left valve only slightly larger than right. Height and thickness subequal. Anterior outline rounded with moderately long, steep slope to venter; posterior end broadly rounded, rounds abruptly into venter; venter rounded. Prominent, rather broad, median sulcus situated slightly behind middle of carapace. Posterior to sulcus lies a comparatively small node outlined posterio-dorsally by a minor sulcus; anterior to major sulcus lies a large, much inflated swelling which following swing of outline of shell curves ventrad to sulcus, dies out posteriorly. Greatest height of swelling anterio-ventrad to mid-point. A rib slightly concave upward, originating in anterior portion of high area runs posteriorly and somewhat ventrally to posterior base of swelling, lies nearly along top of swelling. Small upright, "L" shaped rib lies slightly below posterior cardinal angle and nearly midway between posterior node and margin. Narrow plain border runs from

angle to angle. Surface finely punctate. In dorsal view the ribs outline swollen areas of carapace.

Dimensions of type specimen; length, .68 mm.; height, .40 mm.; thickness, .43 mm.

Locality G7. Holotype, Walker Museum, No. 44413.

Remarks: This species is somewhat similar to *K. lecta* (Coryell and Rogatz), from the Permian Arryo formation of Texas. It may be distinguished from the latter by its much more nearly equivalved condition, and by its lack of anterior subdorsal ridge. In addition the major ridge on *K. inflata* is more persistent and runs farther toward the posterior margin than does the corresponding structure on *K. lecta*. The "L" shaped ridge of *K. inflata* is not as distinct on the specimen as on the photograph. There is some uncertainty regarding the orientation of this species.

Family Kirkbyidae U and B
Genus KIRKBYA Jones
Kirkbya turrita Croneis and Gale, n. sp.

Plate V, fig. 12

Carapace subrectangular to subsemicircular, elongate, medium sized; hinge line straight. Anterior cardinal angle approximately 90° acute. Anterior outline short, rounding, with long backward swing into the posterior curvatures. Marginal flange and paralleling groove run from angle to angle. Posteriorly from mid-venter to the cardinal angle the flange has a more gentle slope; thus it increases shell height in this section and can be seen in lateral view. Area outlined by this latter structure has a slope rising gradually from the posterior and dorsal borders to a turrit-like anterio-central high. From this area the anterior and ventral slopes to the groove are abrupt. No distinguishable pit is present. Surface punctate.

Dimensions of type specimen: length, .69 mm.; height, .33 mm.; thickness, .18 mm. (single valve).

Locality G 1. Holotype, Walker Museum, No. 44414.

Remarks: The posterior cardinal angle of the holotype is broken, but the outline of the carapace strongly suggests that

the angle in perfect examples should be close to 90°. The illustrated specimen is apparently a young individual because of the long backward swing which is absent in a larger form of this species. Such a change as this is in accord with the characteristic growth modification seen in specimens of the Kirkbyidae. This species is rather similar to *K. regularia,* and *K. punctata* in general appearance. It differs from the latter by having no distinguishable pit, and in possessing a broader and more complicated border posterio-ventrally. Its surface is also more finely punctate. *K. turrita* differs from *K. regularia* by having a narrower border, no distinguishable pit, a less uniformly swollen central area, and finer punctae.

Kirkbya regularia Croneis and Gale, n. sp.

Plate V, fig. 10

Carapace subsemicircular, large; hinge line straight; cardinal angles approximately 90°, very distinct. Dorsal part of posterior outline straight, rounds into venter with a swing which continues to anterior angle with a more or less regularly diminishing curvature. A broad, more or less flat border, widest anteriorly, extends from angle to angle. A regularly swollen area rises abruptly from the inner edge of this border. Top of swollen structure flattened, but slopes gently toward dorsum. Small, elongate pit lies on the flank of the swelling close to the anterior end of the posterio-ventral quarter.

Dimensions of type specimen: length, 1.24 mm.; height, .64 mm.; thickness, .27 mm. (single valve).

Locality G 1. Holotype, Walker Museum, No. 44415.

Remarks: The size of this specimen falls within the upper limit of *K. punctata* Kellett, of the Middle Pennsylvanian of Kansas, but the venter of the latter species is less rounded. Furthermore, the ventral slope from the swollen area in *K. regularia* does not die out posteriorly as it does in *K. punctata.* This species differs from *K. turrita* in that the border of the latter is narrower, and has a distinct groove not present in *K. regularia.* In addition the punctae are larger and more distinct

in *K. regularia*, and the latter does not possess the turret-like anterior prominence of *K. turrita*.

Genus AMPHISSITES Girty

Amphissites golcondensis Croneis and Gale, n. sp.

Plate V, fig. 7

Carapace suboblong, distinctly lobate and ridged, medium sized; hinge line essentially straight, depressed. Cardinal angles obtuse, sharp. Prominent margin and marginal flange extend from angle to angle. Anterior lobe projects dorsally above the hinge line, extends toward venter to a distinct ridge which serves as the ventrad boundary of the swollen lobate area. Posterior lobe reaches greatest thickness at mid-height of carapace. A subcentral swollen oval node, forming high point of carapace, lies dorsal to pit.

Dimensions of type specimen: length, .80 mm.; height, .42 mm.; thickness, .18 mm. (single valve).

Locality G 1. Holotype, Walker Museum, No. 44416.

Remarks: This form resembles *A. warei* Morey in general outline and in the presence of a ventral ridge and swollen central node, but may be distinguished from that species by the prominent anterior and posterior lobes.

Amphissites similis Croneis and Gale, n. sp.

Plate V, fig. 6

Carapace small, suboblong, bearing three transverse lobes; hinge line straight or slightly concave. Heavily rolled border at venter diminishing regularly in prominence as it approaches the blunted cardinal angles. Posterior end of carapace broadly rounded; anterior end less blunt with a more gradual swing into the venter. Anterior and posterior lobes project above hinge line; all lobes isolated, but ventrad end of posterior lobe shows slight anterior swing. Axis of median node an anterior portion of posterior half of carapace. Surface punctate.

Dimensions of type specimen: length, .42 mm.; height, .26 mm.; thickness, .14 mm. (single valve).

Locality G 2. Holotype, Walker Museum, No. 44417.

Remarks: This species is similar to *A. tricollina* (Jones and Kirkby), originally described from the Lower Carboniferous limestone of Great Britain and since found in the Birdsville formation of the Chester in the Mississippi Valley. In *A. tricollina*, however, the lobes are node-like and lie in the dorsal half of the carapace; in *A. similis* they extend ventrally nearly to the border. In addition the ends of the latter species are not nearly as truncated as in the former, and its border is heavier than that of *A. tricollina*.

Amphissites centronotus ? (Ulrich and Bassler)

Plate V, fig. 9

Kirkbya centronotus Ulrich and Bassler, U. S. Nat. Mus. Pr., 30 (1906), p. 159, pl. 11, figs. 16, 17.

Amphissites centronotus Harlton, Jour. Pal., Vol. 1, no. 3 (1927), p. 207, pl. 32, figs. 10a, b.

Dimensions of illustrated specimen: length, 1.00 mm.; height, .58 mm.; thickness, .30 mm. (single valve).

Locality G 1. Hypotype, Walker Museum, No 44418.

Remarks: This and similar specimens, showing considerable individual variation, have been referred to *A. centronotus* with some uncertainty. Suites of individuals from the Elmdale formation referred to *A. centronotus* show, however, about the same amount of variation as do those from the Golconda. The specimens from the latter formation differ slightly from the younger ones in possessing a larger and more abruptly elevated central node. If the present tentative identification is correct, the recorded life span of *A. centronotus* must be considerably lengthened beyond its already extended geologic range.

Amphissites ? *obesus* Croneis and Gale, n. sp.

Plate V, figs. 2–3

Carapace suboblong, about as thick as high; hinge line straight or slightly concave. Prominent elongate pit ventrad to, and slightly posterior to, mid-point of carapace. No distinguishable

nodes or lobes, but the shell is greatly swollen and there are prominent marginal and submarginal flanges visible in lateral, ventral or end views. Surface reticulated in such a fashion that the surface markings suggest fine ridges roughly paralleling the outline of the carapace, this feature being least marked on the dorsal quarter. Ends rather uniformly and nearly equally rounded. Posterior end somewhat more blunt than anterior in dorsal view.

Dimensions of type specimen: length, .80 mm.; height, .44 mm.; thickness, .46 mm.

Locality G 1. Holotype, Walker Museum, No. 44419.

Remarks: This species resembles *A. planoventralis* Geis from the Salem limestone in general appearance, but it lacks the central node of the latter. In addition the marginal and submarginal flanges of *A. ? obesus* are considerably more prominent than the corresponding ornamentation of *A. planoventralis*. It is interesting to note that *A. ? obesus* combines a number of features commonly attributed on the one hand to the genus *Knightina*, on the other to *Amphissites*. Accordingly it has been referred to the latter with some uncertainty.

Amphissites trilobus Croneis and Gale, n. sp.

Plate V, fig. 5

Carapace elongate, suboblong; hinge line straight or slightly concave, depressed; cardinal angles obtuse, rounded. Anterior outline subuniformly rounded, joining venter smoothly; posterior end more bluntly rounded, joins venter rather abruptly. Prominent submarginal flange with bordering groove, encircles slightly more than ventral half of shell. Anterior shoulder prominent. Anterior lobe projects above hinge line, slightly broader than posterior lobe, dies out ventrally somewhat below mid-height of carapace nearly on line with base of median node; posterior lobe projects only slightly above hinge line, narrower and more sharply defined than anterior lobe, extends same distance from hinge line as anterior lobe. Both lobes broadly concave inward. A prominent, isolated, large, subcentral node lies slightly dorsad

and posterior to mid-point of carapace. An ill-defined pit is located at anterio-ventral base of node. Surface finely reticulated, the lines on the lobes and below the node tending to connect and follow general outline of carapace.

Dimensions of type specimen: length, .90 mm.; height, .54 mm.; thickness, .48 mm.

Locality G 1. Holotype, Walker Museum, No. 44420.

Remarks: This species is closely related to *A. tricollina* (Jones and Kirkby), from the Scar limestone at Arnside, Westmoreland. It differs from the latter in that its ends are not as blunt, its anterior and posterior lobes are larger and longer, and its subcentral node is larger and located more posterio-ventrally. In addition the reticulation of *A. trilobus* is finer and less prominent than on *A. tricollina*.

Amphissites superus Croneis and Gale, n. sp.

Plate V, figs. 13–14

Carapace medium sized, suboblong in outline. Hinge line straight, cardinal angles obtuse but distinct, posterior angle sharper than anterior. Both valves characterized by three nodes. The anterior and posterior nodes both rise above hinge line; anterior node being elevated about twice as much as the posterior. The anterior node is a little more than twice as far from the anterior cardinal angle than is the posterior node from the posterior cardinal extremity. The median node occupies most of the anterior part of the dorso-posterior quarter. It is the longest of the nodes and rises at nearly right angles to the plane passing between the valves. Viewed dorsally the median node is at least twice as extended as the next longest—the anterior node. Anteriorly, ventrally, posteriorly the carapace is depressed around the base of the median node, but its dorsal side is about flush with the hinge line. An inconspicuous pit occurs in the carapace on the ventro-posterior side of the median node. Outer and inner margins of carapace extend from angle to angle, the outer margin being most prominent ventro-anteriorly. The curvature of the posterior end is more uniform than the anterior curvature which has a longer swing to the venter.

Dimensions of type specimen: length, .92 mm.; height, .44 mm.; thicknesses, .25–56 mm. (the smaller measurement taken between nodes).

Locality G 6. Holotype, Walker Museum, No. 44421.

Remarks: The exceptional length of the nodes distinguishes this species from other representatives of *Amphissites.*

Genus KNIGHTINA Kellett

Knightina pinguoides Croneis and Gale, n. sp.

Plate V, fig. 15

Carapace suboblong, medium sized; hinge line straight. Cardinal angles rounded, indistinct. A fine non-reticulated border, indistinct in lateral view, runs from angle to angle. A line of small pustules forming a vague outer flange, which runs nearly from angle to angle, rises from the margin, and roughly parallels the shell outline. Anterior-cardinal shoulder has abrupt anterior face, but rounds smoothly into surface behind it. Central node medium sized, distinct, but rather low. Slightly sunken areas on opposite sides of the node, on a posterio-dorsal—anterio-ventral line, aid in demarking the structure. There is also a suggestion of sinuses on either side of node, connecting the sunken areas. A conspicuous pit lies oblique to length of carapace close against the anterio-ventral side of node. Surface reticulated.

Dimensions of type specimen: length, .67 mm.; height, .32 mm.; thickness, .17 mm. (single valve).

Locality G 1. Holotype Walker Museum, No. 44422.

Remarks: This species bears a marked resemblance to *K. pinguis* (Ulrich and Bassler), from the Permian Neva formation of Kansas. It may be distinguished from the latter in being slightly more elongate, in having the node more sharply defined, and in being more finely, but less neatly, reticulated.

Knightina neglecta Croneis and Gale, n. sp.

Plate V, fig. 4

Carapace suboblong, medium sized; hinge line straight. Cardinal angles obtuse, and blunted. Length nearly twice the

height. Surface reticulated; pit anterio-ventral to small node situated slightly posterio-ventral of center of carapace. Anterior end more gently rounded near venter than is the posterior. Anterior lobe, low, gently rounded, reticulated as rest of carapace; anteriorly the lobe rounds abruptly to the anterior margin. Margin narrow and somewhat indistinct with one or possibly two weak parallel ridges.

Dimensions of type specimen: length, .79 mm.; height, .39 mm.

Locality G 1. Holotype, Walker Museum, No. 44423.

Remarks: This species is regarded as a *Knightina* rather than an *Amphissites* because it apparently possesses an anterior shoulder. There is a possibility that the orientation may be reversed.

Knightina nodobliqua Croneis and Gale, n. sp.

Plate V, fig. 1

Carapace suboblong, medium sized; hinge line straight; cardinal angles obtuse, blunted. Outlines of ends broadly rounded, subequal, join venter smoothly; venter straight, essentially parallel to hinge line. Anterior lobe broad, indefinite, dies out in upper portion of ventral half of carapace, rises slightly above hinge line; posterior lobe, small, inconspicuous, nearly at cardinal angle. Median node elongated anterio-dorsally—posterio-ventrally, lies posterior to mid-point of carapace, sub-posterio-central in position. Prominent slightly elongate pit flanks anterio-ventral slope of central node. Outer flange and adjacent groove border venter, anterio-ventral, and posterio-ventral slopes. Surface reticulated with a pattern apparently following outline of carapace.

Dimensions of type specimen: length, .90 mm.; height, .45 mm.; thickness, .25 mm. (single valve).

Locality G 1. Holotype, Walker Museum, No. 44424.

Remarks: This species resembles several other species of *Knightina* from the Chester series, but it may be distinguished from them by its relatively inconspicuous posterior lobe and by its elongate, oblique, centrally placed node.

Genus VERRUCOSELLA Croneis and Gale, n. gen.

Carapace small, subovate to suboblong; hinge line straight; valves essentially equal. Prominent nodes arranged in orderly fashion rim the carapace just within its outline. Small median sulcus lies slightly behind middle of shell, and a more or less distinct, but narrow margin borders the valves from angle to angle.

Genotype: *Verrucosella golcondensis* Croneis and Gale, n. sp.

Remarks: This genus is referred to the *Kirkbyidae*, with some certainty in spite of the fact that the valves are nearly or quite equal. The new genus may be distinguished from *Mauryella*, which it superficially resembles, by its possession of a border and median sulcus. In addition *Verrucosella* displays a more orderly node arrangement than does *Mauryella*.

Verrucosella golcondensis Croneis and Gale, n. sp.

Plate V, fig. 8

Carapace small, suboblong; hinge line straight; valves essentially equal. Posterior cardinal angle obtuse, distinct; anterior angle rounded, and indefinite. Anterior end nearly uniformly rounded, joins venter smoothly; venter about straight, much closer to hinge line anteriorly, rounds into short posterio-ventral slope; the latter rounds abruptly into the posterior outline; posterior slopes only slightly convex to junction with cardinal angle. Greatest height of shell posterio-central in position. Carapace thickens posteriorly to a turrit-like end. Seven distinct, isolated, circular nodes ornament the surface of each valve; three are in line bordering the dorsum; three are in line bordering the venter; the seventh is on the posterior shoulder at about mid-height of carapace. A small median sulcus lies close to the anterior end of the posterio-dorsal quarter between the posterior and median dorsal nodes. A distinct but narrow margin borders the carapace from angle to angle. Surface strongly reticulated; nodes smooth or very slightly reticulated.

Dimensions of type specimen: length, .52 mm.; height, .28 mm.; thickness, .20 mm.

Locality G 2. Holotype, Walker Museum, No. 44425.

Remarks: This species is not likely to be confused with any other ostracodes save the more ornate representatives of the genus *Mauryella*. The latter, however, will lack the median sulcus, will show a much less regular scheme of node arrangement, and will not have a border.

Genus DISCOIDELLA Croneis and Gale, n. gen.

Hinge line short, straight, or nearly so; left valve overlaps right along free margin. Outline nearly circular. No sulcus; may or may not possess a pit in ventral half.

Genotype: *Discoidella simplex* Croneis and Gale, n. sp.

Discoidella simplex Croneis and Gale, n. sp.

Plate V, figs. 16–17

Carapace small, subcircular; hinge line straight or nearly so; cardinal angles obtuse somewhat blunted posterior less rounded; left valve overlaps right along free margin. Anterior end rounds from angle into venter with a broad and sub-uniform curvature; posterior end bulges somewhat in ventral half of carapace, rounds smoothly into rounded venter. No distinguishable lobes or nodes present. Area of greatest thickness is in anterio-dorsal portion. Slightly depressed area lies ventral to mid-point of shell. An ill-defined longitudinally elongate pit lies in this area. An inconspicuous, reticulated border runs from angle to angle becoming strongest ventrally. Surface of carapace coarsely and neatly reticulated.

Dimensions of type specimen: length, .31 mm.; height, .28 mm.; thickness, .12 mm.

Locality G 2. Holotype, Walker Museum, No. 44426.

Remarks: This genus is referred to the *Kirkbyidae*. It possesses the strong anterior shoulder characteristic of the genus *Knightina*.

Genus WORKMANELLA Croneis and Gale, n. gen.

Hinge line straight; cardinal angles rounded as in *Knightina*. Median sulcus extending posterio-ventrally separating two

swellings. The posterior swelling has a more or less spine-like termination which may or may not protrude over posterio-ventral slope.

Genotype: *Workmanella distincta* Croneis and Gale, n. sp.

Workmanella distincta Croneis and Gale, n. sp.

Plate V, fig. 11

Carapace small, subsemicircular in outline; thickness greater than height; hinge line straight or very slightly concave. A globose swelling, nearly parallel to backward swing of carapace, lies in ventral half with anterior end traceable into an anterior lobe. Posterior to this structure lies a smaller one with its axis at a greater angle to the hinge line. The posterior end of this latter prominence protrudes over the posterio-ventral slope with a more or less spine-like termination. A well-defined median sulcus extending in a posterio-ventral direction separates the swellings. The larger swelling falls off abruptly nearly to the ventral margin; ventrally, and anterio-ventrally the carapace is compressed. Anterior end of carapace rounds gradually up to base of swelling. Surface reticulated, or uniformly pitted.

Dimensions of type specimen: length, .57 mm.; height, .32 mm.; thickness, .34 mm.

Locality G 2. Holotype, Walker Museum, No. 44427.

Remarks: Overlap has not been determined; apparently it is not pronounced.

Family Glyptopleuridae Girty

Genus GLYPLOPLEURA Girty

Glyptopleura decacostata Croneis and Gale, n. sp.

Plate VI, fig. 5

Carapace subsemicircular, medium sized; hinge line straight. The submarginal dorsal and ventral ribs partially enclose four major ribs of which the outer join anteriorly. The pit, which is located in the posterio-ventral corner of the anterio-dorsal quarter, lies between the two uppermost major ribs. Minor ribs are located as follows: one occurs on anterio-dorsal quarter,

dorsad to first rib above pit, a second appears anterior to the pit, a third rather inconspicuous one lies posterior to the pit, and the fourth, which is the strongest of the minor ribs, occurs dorsad to the submarginal ventral rib. Posteriorly all ribs terminate abruptly leaving a conspicuous portion of the posterior part of the carapace unornamented. Posterior end rounds smoothly from end of ribs to margin.

Dimensions of type specimen: length, .94 mm.; height, .54 mm.; thickness, .17 mm. (single valve).

Locality G 1. Holotype, Walker Museum, No. 44428.

Remarks: This species is similar to *G. multicostata* Morey, from the Amsden formation of Wyoming. It differs from the latter as follows: the first and third ribs below the pit are more nearly straight, and the rib posterior to the pit is less prominent. *G. decacostata* also possesses a short rib anterior to the pit, which does not occur in *G. multicostata*. It should be noted in addition that these two species, as presently described, are differently oriented.

Glyptopleura conflexacostata Croneis and Gale, n. sp.

Plate VI, fig. 7

Carapace subovate to suboblong, medium sized; hinge line straight; both ends nearly uniformly rounded. A ventrad submarginal ridge swings posteriorly to the posterio-dorsal area where it approaches but fails to meet an inconspicuous submarginal dorsad ridge. Partially enclosed by these weak submarginal ridges lie four major ribs, the ventrad of which is the weakest. The dorsal major rib, which is essentially parallel to the hinge line, terminates in a sharp ventro-anteriorly directed extension. Anterior ends of all ribs more or less connected by submarginal ridge. An indistinct pit probably occurs ventrad to uppermost rib. Carapace gradually thickens posteriorly forming a turrit-like prominence with a finely pitted surface.

Dimensions of type specimen: length, .68 mm.; height, .37 mm.; thickness, .17 mm. (single valve).

Locality G 2. Holotype, Walker Museum, No. 44429.

Remarks: A posterio-central pit, which is prominent in the photograph of the type specimen, is possibly a blemish on the carapace. This species may be distinguished by the sharp bend ventrally of about 60 degrees in the anterior part of rib dorsad to presumed pit.

Glyptopleura intermedia Croneis and Gale, n. sp.

Plate VI, fig. 6

Carapace flat, subovate in outline, medium sized; hinge line straight. Surface marked by a prominent U-shaped ridge with its base anterior in position and slightly ventrad of mid-height; its arms somewhat more nearly parallel each other than the hinge line. One major rib and a faint minor one ventral to it are implanted between the arms of the U-shaped ridge. A prominent circular pit is situated between the upper arm of the U-shaped ridge and the major implanted rib. A minor rib lies near the venter.

Dimensions of type specimen: length, .70 mm.; height, .40 mm.; thickness, not definitely determinable.

Locality G 1. Holotype, Walker Museum, No. 44430.

Remarks: The flatness of the figured specimen possibly may have been caused by slight crushing. This form resembles *G. parvacostata* Geis in its general appearance, and probably is a descendant of that species. In the latter form, however, the arms of the U-shaped ridge are not as nearly parallel, nor are there any ridges implanted within that structure.

Glyptopleura pentacostata Croneis and Gale, n. sp.

Plate VI, fig. 8

Carapace elongate, suboblong, thick; hinge line slightly concave. The most prominent marking is a rib, extending on a submedian posterior-anterior line; anterior end of rib joins the dorsal ridge in two crescentic swings, the first concave toward the posterior, the second concave toward the anterior dorsal angle; posterior end of rib curves dorsally and rounds smoothly into the dorsal ridge. Enclosed by this elongate suboval structure is a

rib, approximately paralleling the major prominence, which terminates posteriorly in a hook with its opening directed anterio-ventrally. Ventrad to the prominent rib lies a fourth rib having the configuration of the former. The latter extends posteriorly into the fifth rib which roughly parallels the margin from the posterior angle to the anterior angle. This fifth rib is overlain anteriorly by the crescentic swings of the above described enclosing structure. Both ends of the carapace round nearly uniformly into the venter. Thickest point of shell subposterio-central near hook of enclosed rib.

Dimensions of type specimen: length, .78 mm.; height, .33 mm.; thickness, .15 mm. (single valve).

Locality G 5. Holotype, Walker Museum, No. 44431.

Remarks: The hinge line appears somewhat damaged. This condition probably causes or accentuates its concavity. This species is one of the strongest and most eccentrically ribbed of all the *Glyptopleura* and may actually represent a new genus.

Glyptopleura gibba Croneis and Gale, n. sp.

Plate VI, figs. 9–10

Carapace subovate, about as thick as high. Hinge line very slightly concave. Prominent pit dorsad and very slightly posterior to mid-point of carapace. Most prominent complete rib lies dorsal to pit, runs roughly ventro-posteriorly—dorso-anteriorly at an angle of 12–15° to the hinge line. A large globose swelling encircles the pit from the anterior-dorsal margin, anterio-ventrally to the posterior border. Ventral to the pit and roughly parallel to the major dorsal rib, are three major ribs and one shorter one. Above the major dorsal rib lies a short one parallel to it. Posterior to this latter ornament is a short transverse rib. Beginning just posterior to this transverse structure is a ridge which encircles the globose swelling ventrally terminating at the anterior margin. This ridge appears more or less to connect the posterior ends of the ribs. A broad margin flanks the swelling anteriorly.

Dimensions of type specimen: length, .90 mm.; height, .54 mm.; thickness, .55 mm.

Locality G 3. Holotype, Walker Museum, No. 44432.

Remarks: The extreme thickness and the dorsal profile of this species make it readily distinguishable from other species of *Glyptopleura.*

Glyptopleura ? *curvata* Croneis and Gale, n. sp.

Plate VI, figs. 15–16

Carapace small, suboblong; hinge line straight. Cardinal angles blunted, somewhat obscure, particularly the anterior angle. Anterior end blunt, rounding slightly to cardinal angle; ventrally it rounds abruptly into short anterio-ventral slope which rounds less abruptly into venter. Greatest height of carapace anterior-central; greatest thickness posterio-central. A prominent central longitudinal sulcus running nearly from end to end of carapace is enclosed in a strong U-shaped ridge whose base lies near anterior margin. Except for a central "break" the upper arm of the "U" becomes gradually higher dorsally toward posterior angle where ridge is hooked back dorsally toward anterior cardinal angle. A small hooked ridge leaves the dorsal side of upper arm directed first anteriorly and finally toward mid-dorsum. On each side of the "break" upper arm bears a very short dorsally directed stub. In sub-center of anterio-ventral quarter on both sides of lower arm of "U" originate small ridges which are directed first anteriorly, then swing sharply posteriorly; the upper of the two ridges ends just short of mid-length of carapace, the lower one is considerably longer. This minor ridge lies about midway between main lower arm of "U" and venter. Posterior to junction of small ridges with lower arm of "U" the arm itself is much heavier than anterior to junction. A very small ridge leaves lower arm of "U" anterior to junction of the two already described ridges, and runs posterio-dorsally almost to venter.

Dimensions of type specimen: length, .44 mm.; height, .27 mm.; thickness, .22 mm.

Locality G 1. Holotype, Walker Museum, No. 44433.

Remarks: Despite the moderately long swing from one end into the venter, this end has been designated posterior because of its much greater thickness. Such an orientation puts the base of the U-shaped ridge anterior, this coincides with the orientation of *Glyptopleurids* used by Geis.

Genus GLYPTOPLEURINA Coryell

Glyptopleurina ? bulbosa Croneis and Gale, n. sp.

Plate VI, fig. 3

Carapace suboblong to subovate; hinge line slightly concave; essentially equi-valved. Cardinal angles rounded, indefinite. Posterior end uniformly curved, rounds smoothly into dorsal and ventral outlines; anterior end somewhat more blunt, but rounding smoothly into dorsal and ventral outlines. Venter approximately parallel to hinge line. Prominent, dorsally expanded, median sulcus in sub-central dorsal area, tapers into a short narrow anterio-ventral extension. Posterior to sulcus lies a medium sized, slightly elongated, posteriorly expanding lobe whose narrow anterior position outlines the sulcus posterio-ventrally. Anterior to sulcus lies a split lobe, the dorso-posterior part of which is broadly expanded; ventrally it continues as a prominent narrow ridge at first extending anterio-ventrally, then swinging sharply backward and slightly upward where it is separated from the posterior lobe by only a fine groove; ridge dies out before reaching posterior end of posterior lobe. Anterior part of anterior lobe less expanded, more elongate than posterior portion; anterio-dorsally the lobe merges smoothly into border of carapace; ventrally it tapers into a ridge which swings posterio-ventrally toward venter, then rounds broadly toward posterior cardinal angle, ending abruptly ventrad of posterior termination of posterior lobe. Between the two major longitudinal ridges lies a weak minor rib. The sinus between minor rib and major dorsal ridge continues forward, then upward to form the split in anterior lobe. Area enclosed by major ventral ridge elevated precipitously above the broad, more or less flat border sur-

rounding the lobes and ridges. Border considerably widened in posterior, particularly posterio-ventrally. Surface apparently smooth.

Dimensions of type specimen: length, .73 mm.; height, .44 mm.; thickness, .25 mm.

Locality G 3. Holotype, Walker Museum, No. 44434.

Remarks: This species differs from known representatives of *Glyptopleurina* in that its orientation is reversed, and that the principal ridges connect anteriorly to what is considered as a split anterior lobe.

Genus GLYPTOPLEUROIDES Croneis and Gale, n. gen.

Similar to *Glyptopleura*, but differs in that the ribs are broader, are enclosed along free margin by a wide border, and are given their relief by the grooves between them rather than being raised above the general carapace level themselves.

Genotype: *Glyptopleuroides insculptus* Croneis and Gale, n. sp.

Glyptopleuroides insculptus Croneis and Gale, n. sp.

Plate VI, fig. 32

Carapace suboblong, medium sized; hinge line straight, slightly depressed; cardinal angles obtuse, blunted. Left valve overlaps the right slightly in mid-ventral region. Anterior outline steep projecting forward from cardinal angle to point about $\frac{1}{3}$ shell height above venter from which it rounds smoothly into venter; posterior outline blunt, rounding abruptly into venter. A groove beginning slightly posterior to anterior cardinal angle on dorsum swings around the anterior end paralleling the margin to anterio-ventral area where it turns abruptly backward and runs first posterio-dorsally and then posteriorly to the posterior transverse ridge, ending in a short, anterio-dorsally directed hook. Ventrad to this major surface feature lies an irregular rib, the posterior end of which joins the posterior transverse ridge, the anterior end swinging into the broad margin in anterio-ventral region. Between its ends this rib is separated from the border by an indistinct ventral groove. Immediately dorsad of major

groove lie two ribs fused at their ends and in anterior half, but having a short groove between them posteriorly, posterior ends join the transverse posterior ridge. Above these two fused ribs lies another groove separating them from the major dorsad rib which swings posterio-ventrally and merges smoothly into the transverse ridge. In the dorso-central area of the anterio-dorsal quarter lies a short transverse sulcus connecting a fine groove running posteriorly from it immediately above the major dorsad rib, and a short oblique groove running from ventrad termination of sulcus to the centro-anterior part of the major groove. Anterior to the sulcus lies a short, thick, nearly node-like, ridge which connects dorsally with a submarginal ridge paralleling the hinge line. A narrow border dying out ventrally lies posterior to the transverse ridge, elsewhere border is broad and raised. Surface of ridges and grooves essentially unornamented.

Dimensions of type specimen: length, .76 mm.; height, .37 mm.; thickness, .27 mm.

Locality G 1. Holotype, Walker Museum, No. 44435.

Genus IDIOMORPHA Croneis and Gale, n. gen.

Similar to *Glyptopleurina*, but differs in being more bulbous particularly in posterio-dorsal quarter, and in possessing a split anterior lobe. In addition the typical marginal flange of *Glyptopleurina* is inconspicuous or wanting in *Idiomorpha*.

Genotype: *Idiomorpha insignis* Croneis and Gale, n. sp.

Remarks: This genus is fairly common in the Golconda formation.

Idiomorpha insignis Croneis and Gale, n. sp.

Plate VI, fig. 4

Carapace suboblong, medium sized, thickest posterio-centrally; hinge line slightly convex; greatest height anterio-central. Posterior cardinal angle rounded and indeterminate; anterior angle obtuse, blunted. Posterior end rounds uniformly into hinge line, and rounds into venter with long "forward swing," anterior end rounds gently to cardinal angle and abruptly to venter.

Prominent median sulcus, dorsad and slightly anterior of center of carapace; ventrad the sulcus divides and forms two grooves, one swinging anteriorly, the other posteriorly. Anterior lobe divided by a sulcus running, first ventrally, then anteriorly, then apparently curving posteriorly below median longitudinal ridge rounding dorsally to join the posterior groove of the median sulcus. The posterior part of the anterior lobe tapers ventrally to a ridge swinging posterior to the anterior sulcus and following its configuration; this ridge terminates posteriorly in an oval expansion. The ridge approaches the hinge line more closely at the posterior than at the anterior. Ridge not raised above general swelling of carapace, its prominence being due to the outlining grooves and sulcus. A margin surrounds the carapace, most prominent dorsally. A furrow borders the margin ventrally. Posterior lobe, broad, indefinite.

Dimensions of type specimen: length, .95 mm.; height, .50 mm.; thickness, .14 mm. (one valve only).

Locality G 1. Holotype, Walker Museum, No. 44436.

Remarks: The markings of this species are so distinctive that it is not likely to be confused with any other ostracode.

Idiomorpha ornata Croneis and Gale, n. sp.

Plate VI, figs. 1–2

Carapace small, suboblong; hinge line straight, depressed; cardinal angles obtuse, blunted, subindistinct. Anterior outline rounded, with curvature continuing to mid-venter; posterior outline has short, nearly straight slope backward from cardinal angle and rounds sharply downward into a long swing joining venter abruptly; ventral outline straight from this point to slightly angulated junction with the anterior curvature. Greatest thickness in dorso-posterior quarter; greatest height anterior. Prominent median sulcus, anterio-ventrally directed, lies slightly forward of mid-carapace. A large globose swelling lies posterior to sinus; anterior to sinus lies anterior lobe split by a conspicuous, broad sinus extending from dorsum, first ventrally, then somewhat anterio-ventrally, then becoming broader and swinging

sharply backward and slightly upward to die out against globose posterior swelling. Posterior portion of anterior lobe is expanded dorsally, but tapers ventrally into a ridge which follows configuration of the major sinus which bounds it anteriorly and ventrally, and finally terminates as does the latter against the posterior swelling. Anterior portion of lobe an elongate flat topped ridge, grooved by a weak sinus; the two ridges thus formed parallel each other and outline the major sinus anteriorly and ventrally. Upper of these two ridges dies out posteriorly against globose swelling, the lower ridge becomes a delicate raised line which swings up over the posterior swelling and roughly parallels the dorso-posterior outline; finally the line swings anteriorly and somewhat ventrally and terminates in median sulcus. A short, straight rib leaves ventral margin at end of anterior swing and extends to posterior base of globose swelling, and roughly parallels that portion of last described ridge which lies dorsad to it. Sinus separating these two structures continues anterio-ventrally and then anterio-dorsally approximately to cardinal angle. In dorsal view anterior three-fourths appears thin and emaciated. Surface essentially smooth.

Dimensions of type specimen: length, .60 mm.; height, .45 mm.; thickness, .29 mm.

Locality G 7. Holotype, Walker Museum, No. 44437.

Remarks: This species may be distinguished from *I. insignis* by its more ornate sculpture, its shorter, more blunt form, and its more globose posterior. It is not likely to be confused with any other ostracode.

Family Bairdiidae Lienenklaus
Genus BAIRDIA McCoy
Bairdia golcondensis Croneis and Gale, n. sp.

Plate VI, figs. 26–27

Carapace small, subrhomboidal in outline, left valve overlapping right prominently along dorsal margin, less prominently along venter, elsewhere overlap is indefinite. Dorso-anterior slope straight; mid-dorsal area straight, sloping posteriorly;

dorso-posterior slope slightly concave, steepest of dorsal slopes when venter is horizontal. Posterio-ventral slope short, nearly straight, rounding gently into venter; anterio-ventral slope rounded, joins venter smooth. Venter slightly concave. Curvature of carapace gradual, convex except near venter and beak. Beak of moderate prominence. Viewed dorsally the overlap is most prominent on the anterio-dorsal slope.

Dimensions of type specimen: length, .66 mm.; height, .33 mm.; thickness, .25 mm.

Locality G 3. Holotype, Walker Museum, No. 44438.

Bairdia cooperi Croneis and Gale, n. sp.

Plate VI, figs. 11–12

Carapace large, subrhomboidal; left valve overlaps right prominently at all points except ends where overlap is less distinct. Overlap particularly swollen on dorso-anterior slope, moderately broad along venter, not swollen elsewhere. Anterio-dorsal outline straight or slightly concave, rounding into mid-dorsal area; mid-dorsal outline, straight, sloped posteriorly, rounding rather abruptly into posterior slope; dorso-posterior slope slightly concave, steep. Ventro-posterior slope short, grading unobtrusively into venter; anterio-ventral slope moderately steep, rounds somewhat abruptly into venter. Central area of carapace only gently rounded but falling steeply to margin; carapace convex except near extreme ends and at venter. Viewed dorsally the overlap of the left valve swings markedly over the right at each end of the mid-dorsal area where a prominent trough-like depression appears.

Dimensions of type specimen: length, 1.42 mm.; height, .86 mm.; thickness, .66 mm.

Locality G 3. Holotype, Walker Museum, No. 44439.

Remarks: *Bairdia cooperi* bears a general resemblance to *B. seminalis* Knight, from the Deer Creek formation, but the latter is smaller, and its most prominent roll, or overlap, is farther posterior. *B. seminalis* also has a more rounded dorsal outline, and less concave slopes from the mid-dorsal section to the anterior border.

Bairdia ? deloi Croneis and Gale, n. sp.

Plate VI, figs. 13–14

Carapace rhomboidal, elongate, smooth, about two and a half times as long as high. Left valve overlaps right prominently along dorsal margin of carapace, very slightly along venter; elsewhere the overlap is absent or extremely indistinct. Dorso-posterior and anterior slopes are straight, or only slightly concave, rounding smoothly into the mid-dorsal area. Dorso-posterior slope longer and steeper than the dorso-anterior and carried nearer to venter. Anterio-ventral slope straight, and roughly parallel to dorso-posterior slope, shorter than either dorso-posterior or anterior slopes. Anterior-ventral slope joins venter in a blunt, obtuse angle. Ventro-posterior slope is shortest of the slopes, rounds gently into venter. Carapace swells gradually to its greatest thickness slightly anterior to center of carapace. Curvature of whole convex except for small concave area adjoining the ventro-anterior slope. Beak scarcely protruding.

Dimensions of specimen: length, 1.35 mm.; height, .55 mm.; thickness, .36 mm.

Locality G 7. Holotype, Walker Museum, No. 44440.

Genus BAIRDIOLITES Croneis and Gale, n. gen.

Like *Bairdia*, in outline and overlap, but differing from that genus in possessing curved ridges similar to, but narrower than, those of *Seminolites*. Two ridges occur on each valve; one is anterio-central in position, the other posterior-central.

Genotype: *Bairdiolites crescentis* Croneis and Gale, n. sp.

Bairdiolites crescentis Croneis and Gale, n. sp.

Plate VI, figs. 19–20

Carapace subrhomboidal, medium sized; left valve overlaps right except at beak. Beak prominent. Anterio-dorsal outline straight, rounding abruptly into mid-dorsal area; mid-dorsal outline longer, straight, sloping posteriorly, rounding somewhat less abruptly into posterio-dorsal slope; posterio-dorsal outline

slightly concave, somewhat steeper than anterio-dorsal slope, shortest of the three dorsal slopes. Posterio-ventral slope slightly convex, rounding rather gently into venter; anterio-ventral slope rounded, junction with venter being only slightly angular. Sides of carapace rise more or less abruptly to central area which is demarked by crescentic ridges, one anterio-central, the other posterio-central; the central area is nearly flat. Anterior ridge more ventral than posterior ridge; both ridges relatively uniform and thin. As in *Bairdia cooperi*, a dorsal view shows that the overlap of left valve swings markedly over the right at each end of the mid-dorsal area where a prominent trough-like depression appears.

Dimensions of type specimen: length, .75 mm.; height, .36 mm.; thickness, .31 mm.

Locality G 3. Holotype, Walker Museum, No. 44441.

Bairdiolites platypleurus Croneis and Gale, n. sp.

Plate VI, fig. 25

Carapace subrhomboidal to suboblong, medium sized. Left valve overlaps right except at beak. Anterio-dorsal outline straight or slightly convex, longest of the three slopes, rounds into mid-dorsal outline; mid-dorsal outline straight or slightly convex, sloping posteriorly, rounds sharply into posterio-dorsal slope; posterio-ventral outline short, rounding smoothly into venter; anterio-ventral outline short, steep, rounds into venter. Two curved ridges on each valve, one anterio-central, the other posterio-central. The surface texture of area between the ridges is coarser than the fine pebble surface elsewhere; curvature of carapace between the ridges distinctly less than that of the slopes rising to this central area. Dorsal view shows trough-like depression in mid-dorsal area, from the extremities of which the left valve swings abruptly over the right.

Dimensions of type specimen: length, .80 mm.; height, .44 mm.; thickness, .35 mm.

Locality G 1. Holotype, Walker Museum, No. 44442.

Remarks: Distinguished from *B. crescentis* by the roughened central area of its carapace, and by its more robust form.

Genus HEALDIA Roundy

Healdia opima Croneis and Gale, n. sp.

Plate VI, figs. 28–29

Carapace small, subovate; left valve appears to overlap the right completely. Anterio-dorsal outline rounds gently from a point about one-third carapace height above venter to a subcentro-dorsal position from which point the posterio-dorsal slope commences; posterio-dorsal slope nearly straight, swings abruptly into posterior end which is bluntly rounded. Ventral outline rounded, curvature increasing away from central area and swinging smoothly into end profiles. The posteriorly directed spines occur at the posterior end of each valve, one on the posterio-dorsal slope, the other on the posterio-ventral slope. A weak irregular ridge connects them. In dorsal view the four spines are visible, the ventrad pair being more extended laterally than the dorsal pair. Carapace swells to greatest thickness posterio-centrally, tapering anteriorly with definite bevel at anterior margin.

Dimensions of type specimen: length, .44 mm.; height, .28 mm.; thickness, .18 mm.

Locality G 1. Holotype, Walker Museum, No. 44443.

Remarks: The spine arrangement of this species resembles that of *Healdia formosa* Harlton, from the Gaptank ? formation, Texas. The carapace of the latter, however, is larger, and more elongate. Viewed dorsally the anterior end of *H. formosa* is decidedly more blunt than in *H. opima*, but the Golconda specimens of the latter possibly are somewhat crushed in the anterior quarter.

Healdia triangularis Croneis and Gale, n. sp.

Plate VI, fig. 22

Carapace small, subtriangular to subovate; left valve larger, overlapping right completely, but not as prominently in the posterior as elsewhere. Anterio-dorsal outline slightly more rounded than the nearly straight posterio-dorsal outline. Out-

lines of ends much alike, but the posterior end is less uniformly rounded and swings more gently into venter. Two small spines connected by a comparatively broad weak ridge lie on a transverse line near the posterior end. A very weak ridge parallels the anterio-dorsal curve of the anterior end. A vague elongate depression extends backward from dorsal end of this ridge. Shell height is about two-thirds the length. Surface essentially smooth.

Dimensions of type specimen: length, .62 mm.; height, .40 mm.; thickness, .24 mm.

Locality G 1. Holotype, Walker Museum, No. 44444.

Remarks: This species differs from *H. opima* in being more sharply triangular, and larger, and in bearing less conspicuous spines. The weak anterior ridge is also a distinctive feature. In addition the sulcus-like dorso-anterior depression, if a genuine shell feature and not a result of carapace injury, is unusual in the genus *Healdia*.

Family Cytherellidae Sars
Genus CYTHERELLA Jones
Cytherella geisi Croneis and Gale, n. sp.

Plate V, fig. 32

Carapace subovate to ovate, medium sized; right valve overlaps left completely, appearing crimped over left valve along dorsum and venter. Height of carapace about two-thirds of length. Outlines of anterior and posterior halves nearly identical, with ends broadly and smoothly rounding into dorsum and venter. Carapace swollen with smooth convex curvature to high point located in anterior end of posterio-ventral quarter. Ventral, posterior, and posterio-dorsal slopes to margin steep; the slope anterio-dorsally much more gentle. Shell flattens into a vague narrow border along ventral, dorsal, and anterior margins, the widest area of flattening being anterio-dorsal. Greatest length of carapace is about two-fifths shell height above venter. A slight grooving may be present just within shell outline along dorsum and venter in posterior two-thirds of shell. Dorsal

view of entire carapace is similar to a streamlined drop of water. Surface marked with a fine pebble finish.

Dimensions of type specimen: length, .78 mm.; height, .51 mm.; thickness, .30 mm.

Locality G 1. Holotype, Walker Museum, No. 44445.

Remarks: Although this species superficially mimics many other ostracodes belonging to this genus, and even to related genera, close examination shows that it is a relatively distinctive type, both as to shape and character of the border.

Genus CAVELLINA Coryell

Cavellina coryelli Croneis and Gale, n. sp.

Plate V, fig. 18

Carapace subovate, medium sized; right valve overlaps the left completely, most prominently along dorsum, less markedly at the venter, least at the ends. Posterio- and anterio-dorsal slopes about equal in length and curvature, both being only slightly convex. Greatest angularities in outline are at ends, about mid-carapace height anteriorly, and about three-fifths shell height above venter posteriorly. Posterio-ventral slope steep, slightly convex, rounds smoothly into venter. From anterior end the carapace gradually swells to high-point in posterio-central area from which point it rounds, at first gradually, and then more steeply to posterior margin. Posterior and ventral slopes of carapace steeper than anterior and dorsal slopes respectively.

Dimensions of type specimen: length, .83 mm.; height, .52 mm.; thickness, .32 mm.

Locality G 1. Holotype, Walker Museum, No. 44446.

Remarks: This species is somewhat similar to *C. nebrascensis* (Geinitz), from the Permian Elmdale formation of Kansas. In the latter, however, the dorsal slopes are less steep, and dorsal and ventral overlaps are more nearly equal than in *C. coryelli*. *C. pulchella* Coryell, from the Pennsylvanian of Oklahoma, resembles *C. coryelli* in type of overlap, but is more elongate and has a more prominently acute dorso-posterior cardinal angle. Despite these differences, there is little question that these three

species are closely related, and that this type of ostracode had a very long range in the late Paleozoic, exhibiting only minor changes even from the Chester to the Permian.

Genus MICROCHEILINELLA Geis

Microcheilinella pergracilis Croneis and Gale, n. sp.

Plate VI, figs. 23–24

Carapace small, elongate, suboblong; left valve overlaps right completely, overlapping portion thin, most distinct anteriorly. Ventral outline straight, dorsum nearly so to posterio-dorsal outline which in turn is nearly straight. Posterior end semitruncate, rounds rather uniformly into venter; anterior end more broadly and uniformly rounded, joins venter smoothly. Carapace swells gradually on all sides to posterior-central high on right valve, and a sub-central high on left valve. In dorsal view posterior end is rather blunt, anterior end compressed, the whole somewhat wedge-like. Surface smooth.

Dimensions of type specimen: length, .57 mm.; height, .24 mm.; thickness, .18 mm.

Locality G 4. Holotype, Walker Museum, No. 44447.

Remarks: This species is closely related to *M. distortus* Geis, from the Salem limestone. It differs from the latter in being longer, thinner in proportion to its height, and in possessing a distinct posterio-dorsal slope.

GOLCONDA LOCALITY INDEX (ILLINOIS)

Notations, This Paper	*Illinois Geological Survey Register Notations*		*Geographic Locations*
Locality G1	0225.70	P10 Sp. A.	Golconda limestone and shale in road cut near Douglas School, Hardin County
Locality G2	0726.82		Golconda formation in old quarry west of railroad track in S.E. ¼, Sec. 26, 3¼ miles southeast of Waltersburg, Pope County
Locality G3	0705.90		Golconda formation presumably in bluff, west bank of Lusk Creek 2 miles north of Waltersburg, Pope County

Notations, This Paper	*Register Notations*		*Geographic Locations*
Locality G4	0414.56	P26 I	Golconda formation exposed where Brushy Fork cuts west bank just north of center of Sec. 14, 2 miles northwest of Hicks, Hardin County
Locality G5	0616.88	P13 Sp. D.	Golconda shale, light gray, fossiliferous, N.E. ¼, Sec. 16, T. 12 S., R. 7 E., Hardin County
Locality G6	0324.04	P15 Sp. C.	Golconda formation in road cut 1¼ miles northeast of Gross, Hardin County. Sample from shaly limestone with thin shale layers.
Locality G7	W.595		Golconda formation southwest of Ruma, Randolph County; Stuart Weller location?

BIBLIOGRAPHY

BASSLER, R. S., AND KELLETT, BETTY, "Bibliographic Index of Paleozoic Ostracoda," *Geological Society of America, Special* Papers, No. 1 (1934). This index is arranged by periods and formations as well as by species. All references to ostracode papers published prior to January 1, 1934 are included in it.

COOPER, C. L., "Ammonium Chloride Sublimate Apparatus," *Journal of Paleontology*, Vol. 9 (1935) No. 4, pp. 357–359.

CORYELL, N. H., AND WILLIAMSON, MARJORIE, "A Study of the Ostracoda Fauna of the Waldon Shale, Flat Rock Creek, St. Paul, Indiana," *American Museum Novitates*, No. 870 (1936), pp. 1–7.

CRONEIS, CAREY, AND FUNKHOUSER, HAROLD, "New Ostracodes from the Clore Formation," Den. Univ. Bull., Jour. Sci. Lab., Vol. XXXIII, Dec. 1938.

CRONEIS, CAREY, AND THURMAN, FRANKLIN A., "New Ostracodes from the Kinkaid Formation," Den. Univ. Bull., Jour. Sci. Lab., Vol. XXXIII. Dec. 1938.

KELLETT, BETTY, "Ostracodes from the Upper Pennsylvanian and Lower Permian Strata of Kansas: II. The Genus Bairdia," *Journal of Paleontology*, Vol. 8 (1934), pp. 120–138, pls. 14–19.

———, "Ostracodes from the Upper Pennsylvanian and the Lower Permian Strata of Kansas: III. Bairdiidae (concluded), Cytherellidae, Cypridinidae, Entomoconchidae, Cytheridae, and Cypridae," *Journal of Paleontology*, Vol. 9 (1935), pp. 132–166, pls. 16–18.

MOREY, P. S., "Ostracoda from Basal Mississippian Sandstone in Central Missouri," *Journal of Paleontology*, Vol. 9 (1935), pp. 316–326, pl. 28.

———, "Ostracoda from the Amsden Formation of Wyoming," *Journal of Paleontology*, Vol. 9 (1935), pp. 474–482.

———, "Ostracoda from the Chouteau Formation of Missouri," *Journal of Paleontology*, Vol. 10 (1936), pp. 114–122, pl. 17.

PAYNE, K. A., "Pennsylvanian Ostracoda from Sullivan County, Indiana," *Journal of Paleontology*, Vol. 11 (1937), pp. 276–288, pls. 38–40.

SWARTZ, F. M., "Revision of the Primitiidae and Beyrichiidae with New Ostracoda from the Lower Devonian of Pennsylvania," *Journal of Paleontology*, Vol. 10 (1936), pp. 541–586, pls. 78–89.

WELLER, STUART, "The Geology of Hardin County," *Illinois State Geological Survey*, Bull. No. 41 (1920), pp. 178–87.

WELLER, STUART, AND ST. CLAIR, STUART, "Geology of Ste. Genevieve County, Missouri," *Missouri Bureau of Geology and Mines*, Vol. 22 (1928), 2nd series, p. 245.

EXPLANATION OF PLATE V

(All figures, except 9, are of holotypes; magnifications are approximations accurate to within 4 percent.)

Fig. 1. *Knightina nodobliqua* Croneis and Gale, n. sp.; left valve, ×30.

Figs. 2–3. *Amphissites obesus* Croneis and Gale, n. sp.; fig. 2, left valve, ×30; fig. 3, dorsal view, ×30.

Fig. 4. *Knightina neglecta* Croneis and Gale, n. sp.; left valve, ×30.

Fig. 5. *Amphissites trilobus* Croneis and Gale, n. sp.; right valve, ×30.

Fig. 6. *Amphissites similis* Croneis and Gale, n. sp.; left valve, ×50.

Fig. 7. *Amphissites golcondensis* Croneis and Gale, n. sp.; left valve, ×30.

Fig. 8. *Verrucosella golcondensis* Croneis and Gale, n. gen., n. sp.; left valve, ×50.

Fig. 9. *Amphissites centronotus* ? (Ulrich and Bassler), right valve, ×30.

Fig. 10. *Kirkbya regularia* Croneis and Gale, n. sp.; left valve, ×30.

Fig. 11. *Workmanella distincta* Croneis and Gale, n. gen., n. sp.; left valve, ×50.

Fig. 12. *Kirkbya turrita* Croneis and Gale, n. sp.; right valve, ×30.

Figs. 13–14. *Amphissites superus* Croneis and Gale, n. sp.; fig. 13, left valve, ×30; fig. 14, dorsal view, ×30.

Fig. 15. *Knightina pinguoides* Croneis and Gale, n. sp.; right valve, ×30.

Figs. 16–17. *Discoidella simplex* Croneis and Gale, n. gen., n. sp.; fig. 16, left valve, ×50; fig. 17, dorsal view, ×50.

Fig. 18. *Cavellina coryelli* Croneis and Gale, n. sp.; left valve, ×30.

Fig. 19. *Leightonella torta* Croneis and Gale, n. gen., n. sp.; right valve, ×30.

Fig. 20. *Leperditia juvenis* Croneis and Gale, n. sp.; left valve, ×50.

Figs. 21–22. *Monoceratina furcula* Croneis and Gale, n. sp.; fig. 21, right valve, ×30; fig. 22, ventral view, ×30.

Fig. 23. *Perprimitia robusta* Croneis and Gale, n. gen., n. sp.; right valve, ×30.

Fig. 24. *Perprimitia ? bicornis* Croneis and Gale, n. sp.; right valve, ×30.

Figs. 25–27. *Pterocodella mirablilis* Croneis and Gale, n. gen., n. sp.; fig. 25, right valve, ×30; fig. 26, ventral view, ×30; fig. 27, dorsal view, ×30.

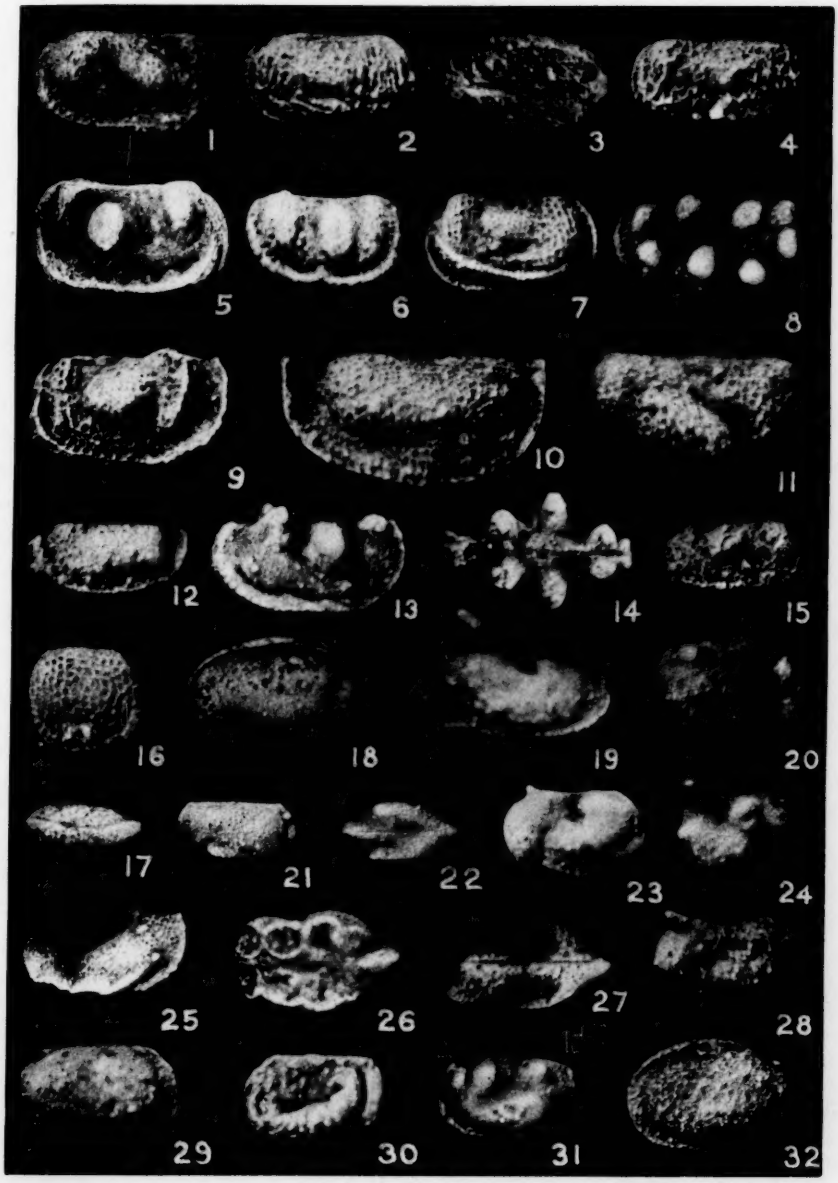
Fig. 28. *Perprimitia spinosa* Croneis and Gale, n. sp.; right valve, ×30.

Fig. 29. *Jonesina ? dubia* Croneis and Gale, n. sp.; right valve, ×30.

Fig. 30. *Golcondella sulcata* Croneis and Gale, n. gen., n. sp.; left valve, ×30.

Fig. 31. *Beyrichia placida* Croneis and Gale, n. sp.; left valve, ×30.

Fig. 32. *Cytherella geisi* Croneis and Gale, n. sp.; left valve, ×30.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EXPLANATION OF PLATE VI

(All figures, except 33, are of holotypes; magnifications are approximations accurate to within 4 percent.)

Figs. 1–2. *Idiomorpha ornata* Croneis and Gale, n. gen., n. sp.; fig. 1, right valve, ×30; fig. 2, dorsal view, ×30.

Fig. 3. *Glyptopleurina ? bulbosa* Croneis and Gale, n. sp.; left valve, ×30.

Fig. 4. *Idiomorpha insignis* Croneis and Gale, n. sp.; right valve, ×30.

Fig. 5. *Glyptopleura decacostata* Croneis and Gale, n. sp.; right valve, ×30.

Fig. 6. *Glyptopleura intermidia* Croneis and Gale, n. sp.; left valve, ×30.

Fig. 7. *Glyptopleura conflexacostata* Croneis and Gale, n. sp.; left valve, ×30.

Fig. 8. *Glyptopleura pentacostata* Croneis and Gale, n. sp.; right valve, ×30.

Figs. 9–10. *Glyptopleura gibba* Croneis and Gale, n. sp.; fig. 9; dorsal view, ×30; fig. 10, left valve, ×30.

Figs. 11–12. *Bairdia cooperi* Croneis and Gale, n. sp.; fig. 11, right valve, ×30; fig. 12, dorsal view, ×30.

Figs. 13–14. *Bairdia ? deloi* Croneis and Gale, n. sp.; fig. 13, right valve, ×30; fig. 14, dorsal view, ×30.

Figs. 15–16. *Glyptopleura ? curvata* Croneis and Gale, n. sp.; fig. 15, dorsal view, ×50; fig. 16, right valve, ×50.

Figs. 17–18. *Knoxina inflata* Croneis and Gale, n. sp.; fig. 17, left valve, ×30; fig. 18, dorsal view, ×30.

Figs. 19–20. *Bairdiolites crescentis* Croneis and Gale, n. gen., n. sp.; fig. 19, right valve, ×30; fig. 20, dorsal view, ×30.

Fig. 21. *Jonesina persulcata* Croneis and Gale, n. sp.; right valve, ×30.

Fig. 22. *Healdia triangularis* Croneis and Gale, n. sp.; right valve, ×30.

Figs. 23–24. *Microcheilinella pergracilis* Croneis and Gale, n. sp.; fig. 23, right valve, ×30; fig. 24, dorsal view, ×30.

Fig. 25. *Bairdiolites platypleurus* Croneis and Gale, n. gen., n. sp.; right valve, ×30.

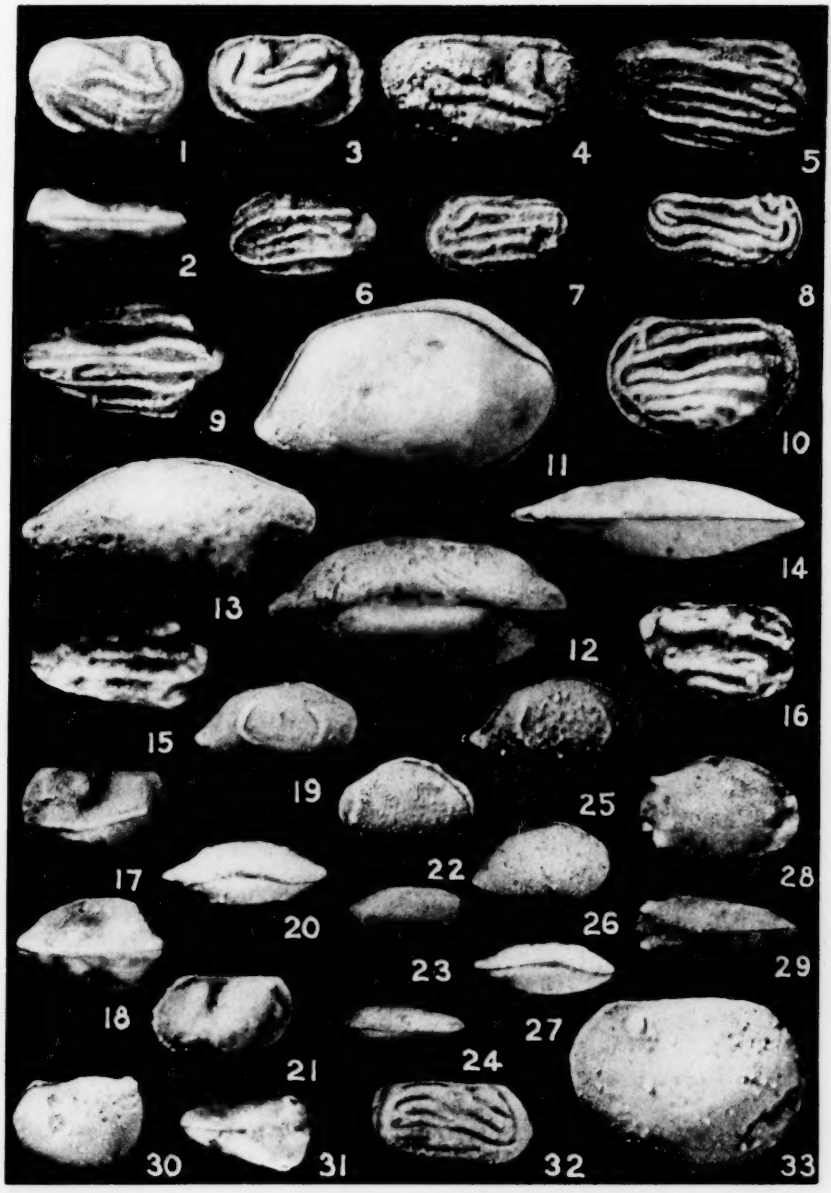
Figs. 26–27. *Bairdia golcondensis* Croneis and Gale, n. sp.; fig. 26, right valve, ×30; fig. 27, dorsal view, ×30.

Figs. 28–29. *Healdia opima* Croneis and Gale, n. sp.; fig. 28, right valve, ×50; fig. 29, dorsal view, ×50.

Figs. 30–31. *Microparaparchites spinosus* Croneis and Gale, n. gen., n. sp.; fig. 30, left valve, ×30; fig. 31, dorsal view, ×30.

Fig. 32. *Glyptopleuroides insculptus*, Croneis and Gale, n. gen., n. sp.; right valve, ×30.

Fig. 33. *Paraparchites inornatus* (McCoy), left valve, ×30.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NEW OSTRACODES FROM THE KINKAID FORMATION[1]

CAREY CRONEIS AND FRANKLIN A. THURMAN

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INTRODUCTION

A number of years ago, at the suggestion of Dr. M. M. Leighton, the senior author undertook the micropaleontologic study of the Chester (late Mississippian) sediments of Illinois. Although this general investigation is still far from completed, recent drilling activity in the Illinois oil basin has made it imperative that at least progress reports be published on the studies of the fossil ostracodes. This is particularly true, since representatives of this group can be employed in the subsurface correlation of the Chester sediments commonly penetrated in the search for oil. Therefore, there are described in this paper some of the new species of ostracodes which should be encountered in well cuttings from the Kinkaid formation.[2]

ACKNOWLEDGMENTS

The material yielding the ostracodes described in this paper was obtained from the outcrops of the Kinkaid formation in southern Illinois. Most of the collecting was done by Mr. L. E. Workman and Mr. J. E. Lamar of the Illinois Geological Survey, or by members of that organization under their direct supervision. Some of the ostracodes had also been sorted out and studied in a preliminary way by Mr. J. E. Lamar before the samples were sent to Walker Museum. To both of these men and their staffs, and especially to Dr. M. M. Leighton, Chief of

[1] Published with permission of Dr. M. M. Leighton, Chief, Illinois Geological Survey.

[2] For a more detailed Introduction and a more complete Acknowledgment applicable to all three ostracode papers in this number of the JOURNAL, see Croneis and Gale (1938).

the Illinois Geological Survey, we are pleased to acknowledge our indebtedness. We are also under obligations to a long list of anonymous, but not forgotten, graduate students whose sample preparation and preliminary sorting of the fossils facilitated not only the micropaleontologic study of the Kinkaid, but of all the other fossiliferous Chester formations. Finally, we are indebted to Mr. Michael S. Chappers for photographic assistance.

THE KINKAID FORMATION

The Kinkaid formation occurs at the top of the Upper Mississippian Chester Series as is shown in the accompanying table of Illinoian Chester formations.

KINKAID limestone and shale
Degonia sandstone
Clore limestone and shale
Palestine sandstone
Menard limestone and shale
Waltersburg sandstone
Vienna limestone and shale
Tar Springs sandstone
Glen Dean limestone and shale
Hardinsburg sandstone
Golconda limestone and shale
Cypress sandstone
Paint Creek limestone and shale
Bethel sandstone
Renault limestone and shale
Aux Vases sandstone

Weller (1920) says of its stratigraphic relations, "No evidence is at hand to indicate that a stratigraphic break separates the two formations (Kinkaid and Degonia). The upper of the Kinkaid limestone is everywhere marked by the sub-Pennsylvanian unconformity (sic) that is present throughout the entire Illinois basin."

The lithology of the Kinkaid resembles that of the other predominantly limey formations of the Chester. The beds consist of limestone and shale with locally some thin minor beds of

sandstone. The limestone is a hard, dense, compact stone, having a conchoidal splintery fracture. The rock is yellow, gray, or black in color, the yellow layers forming a conspicuous feature of many outcrops. Another notable feature of the Kinkaid formation is its high chert content. The shales of the formation are varied in character and color. They range from thin partings to beds more than fifteen feet thick. The formation in Hardin County, Illinois, is more than one hundred feet thick, and well records indicate a possible thickness of one hundred fifty feet.

In speaking of the paleontology of the Kinkaid formation, Weller, (1920) says, "Most of the limestone beds in the Kinkaid formation are more or less fossiliferous, but the fossils are not generally preserved in such a manner as to be properly identified. The shale beds of the formation are commonly very little if at all calcareous, and are likely to be barren of fossils, this being especially true of the red and olive-green shales. . . . This fauna has nothing strikingly distinctive about it, and were not its horizon definitely fixed by its stratigraphic relations it might be considered as of middle Chester age."

The Kinkaid formation of southern Illinois is not to be confused with the recently proposed Kincaid formation of Texas. Miss Julia Gardner (1933) of the U. S. Geological Survey, in naming the Kincaid says of it, ". . . Kincaid, from the Kincaid ranch in southeastern Uvalde County, is here submitted for the beds in Texas overlying the Cretaceous and overlain by the upper Midway, or Wills Point formation. . . . .the name Kincaid is reasonably short and has a certain individuality that inhibits confusion with other formation names." Despite the fact that the two names are spelled differently, the pronunciation is the same. In order to "inhibit confusion" therefore the name Kincaid for the Texas formation should be suppressed in view of the priority of the term Kinkaid for the upper formation of the Chester series in southern Illinois.

KINKAID OSTRACODES

The Kinkaid ostracode fauna herein described is represented by twenty-seven new species belonging to fifteen genera, one of

which is new. The forms are typically late Mississippian in aspect but are distinctive enough to make reasonably certain the identification of the horizon in which they occur.

Of the few ostracode faunas available for comparison, the Kinkaid species resemble most closely those of the Clore. There are, however, real differences in their faunal aspects despite the similarity of some forms, which on further study may prove to be conspecific. Comparing the Kinkaid species with types from the Golconda formation a similarity is also seen to exist, but as is to be expected, the Golconda ostracodes are not as closely allied to the Kinkaid representatives as those from the Clore. The work on the Renault-Shetlerville fauna indicates that it, too, is allied to that of the Kinkaid, but the early and late Chester formations are easily distinguishable on the basis of their ostracodes.

The Amsden formation of Wyoming appears, on the basis of its described ostracodes, to be of an age not very different from that of the Kinkaid. There are, however, notable faunal differences between the two formations which may be due to geographic location rather than to any long time intervals separating their deposition. Although the Amsden has been tentatively identified as Ste. Genevieve in age [Morey (1935)], the formation, on the basis of its ostracodes, may be as young as middle Chester; possibly it may be late Chester in age.

The Kinkaid ostracodes are markedly similar to some Pennsylvanian forms. Particularly is this true of species of *Amphissites* and *Kirkbya*. Species of other genera, however, do not seem to be as closely related to the younger forms.

The primary types of the new species of ostracodes described in this paper are deposited in Walker Museum, University of Chicago. Comparative material will be placed on file at the Illinois Geological Survey.

LABORATORY PROCEDURE

A synopsis of the method of preparing samples and sorting the sediments, together with a brief statement of the photographic procedure, will be found in Croneis and Gale (1938).

SYSTEMATIC DESCRIPTIONS

Class CRUSTACEA

Superorder OSTRACODA Latreille

Family Leperditellidae U. and B.

Genus PARAPARCHITES U. and B.

Paraparchites kinkaidensis Croneis and Thurman, n. sp.

Plate VII, fig. 22

Carapace subovate in outline, medium sized; hinge line straight, simple; cardinal angles obtuse; posterior outline much more broadly rounded than anterior outline; venter convex, with greatest point of convexity posterior giving carapace outline a pronounced backward swing; anterior swing tends toward angularity immediately below anterior cardinal angle. Right valve larger than left and overlaps it along free margin from anterior cardinal angle to mid-posterio-ventral swing; area of greatest overlap along anterior outline; overlap becoming progressively less posteriorly until it dies out. Point of greatest thickness near mid-carapace; surface slopes gently from this area to valve edge; no abrupt slopes present. Surface smooth, almost uniformly convex. "Eye spot" or vague node located in dorso-anterior quarter.

Dimensions of type specimen: length, .82 mm.; height, .63 mm.; thickness, .39 mm.

Locality K3. Holotype, Walker Museum, No. 44500.

Remarks: This is a representative of a very long ranged general type. It can, however, be distinguished from *P. inornatus* (McCoy) of the Golconda formation in that the former is more precipitous along the anterior outline and has no overlap along the posterior. *P. kinkaidensis* differs from *P. nicklesi* (Ulrich) from the Amsden formation, in that the former does not show the posterior overlap seen on the latter.

Genus PSEUDOPARAPARCHITES Kellett

Pseudoparaparchites (?) *aclis* Croneis and Thurman, n. sp.

Plate VII, fig. 12

Carapace subovate in outline, very small; hinge line straight or slightly convex; cardinal angles obtuse, the anterior angle

being the more obtuse; anterior angle measures approximately 120°, while the posterior is only slightly over 100°; anterior and posterior outlines broadly rounded, anterior being more evenly rounded than posterior; ventral margin broadly rounded, convex. Greatest height posterior, just anterior to spine base. Greatest thickness of carapace somewhat ventrad of spine base; from this area surface slopes most abruptly to posterior, less steeply to posterior ventral swing, with most gentle slopes toward anterior and venter. Moderately long sharp spine located in posterior dorsal position, near posterior cardinal angle; spine base small, but expanding gradually into carapace swelling. Surface covered with minute pits and tubercles.

Dimensions of type specimen: length, .46 mm.; height, .35 mm.; thickness (one valve), .15 mm.

Locality K8. Holotype, Walker Museum, No. 44501.

Remarks: This species seems to be considerably atypical for the genus. If further material actually indicates that the tentative generic reference is the correct one, the known range of *Pseudoparaparchites* will be extended back into the Mississippian. The problem of the orientation of the genus will also have to be reconsidered, since in *P.* (?) *aclis* it is the reverse of that employed in the description of the genotype. The genus typically also lacks the pitted surface seen in this Kinkaid form.

Genus SANSABELLA Roundy

Sansabella laevis Croneis and Thurman, n. sp.

Plate VII, figs. 13–14

Carapace subquadrate to subovate, elongate, medium sized. Hinge line straight, depressed; cardinal angles obtuse; posterior and anterior outline broadly rounded; posterior outline tends toward angularity toward mid-height; ventral outline of right valve convex; left valve ventral outline less convex and more evenly rounded than right valve; right valve larger than left and completely overlaps it along free margin; overlap along posterior relatively slight; greatest overlap along venter; anterior overlap less than ventral but greater than posterior; dorsal view shows

overlap beginning abruptly at termination of hinge line. Greatest thickness of carapace anterior, midway between sulcus and anterior swing; slope steepest toward anterio-ventral swing; elsewhere the surface slopes roundly to valve edge. Shallow pit or sulcus located posterior and slightly dorsad of mid-carapace. Slight upward swelling extending along hinge line in mid-anterior region. Surface smooth.

Dimensions of type specimen: length, .72 mm.; height, .48 mm.; thickness, .36 mm.

Locality K2. Holotype, Walker Museum, No. 44502.

Remarks: *S. laevis* differs from *S. sulcata* Roundy of the Barnett formation in that the sulcus of the former is located posterior of vertical median line, whereas in the latter it is anterior of the corresponding line. *S. laevis* is very similar to *S. harrisi* of the Clore formation, but on comparison of type material it is seen that they differ in that the former has a comparatively greater thickness. Sulcus on the former is much better developed and extends to dorsal outline, whereas on the latter it is not as conspicuous when viewed dorsally. Further study, however, may show these forms to be more closely allied than they are thought to be at present. *S. laevis* is oriented after the manner described by Geis in the Journal of Paleontology, Vol. VI, No. 2, pp. 150–155.

Family Primitiidae U. and B.

Genus CARBOPRIMITIA Croneis and Funkhouser

Carboprimitia simulans Croneis and Thurman, n. sp.

Plate VII, figs. 23–25

Carapace subquardate to subovate in outline, large; hinge line straight, depressed; hingement simple; cardinal angles obtuse; posterior somewhat more broadly rounded than anterior; ventral outline convex. Right valve larger than left and overlaps it along free margin; interior of free margin of right valve channelled to receive left valve; ventral outline of right valve more broadly rounded than ventral outline of left valve; ventral overlap greatest; posterior overlap greater than anterior. Posterio-

ventrad of mid-carapace is located a deep pit or sulcus; anterior edge of left valve marked by a groove or step-like structure paralleling anterior swing and dying out toward the dorsal and ventral outlines; anterio-dorsad of left valve pit there is a lobe like swelling much larger than corresponding swelling on right valve, and it rises more prominently above hinge line. Thickest portion of carapace just posterior of pit; remainder of surface almost same elevation, with exception of pit depression and marginal depressions to outline. Surface smooth.

Dimensions of type specimen: length, 1.06 mm.; height, .75 mm.; thickness, .51 mm.

Locality K3. Holotype, Walker Museum, No. 44503.

Remarks: *C. simulans* differs from *C. rotunda* of the Clore formation in that the former shows a greater tumidity of overlap, particularly on anterio-ventral and posterio-ventral swings. The step-like groove on anterior of left valve is much more pronounced on the former than on the latter in which form it is more of a simple slope indentation. At first glance the genus *Carboprimitia* somewhat resembles *Sansabella*, the similarity being a matter of carapace outlines and node arrangements. With closer study, however, it is seen that the differences are very marked. The sulcus is anterior on *Carboprimitia*, whereas on *Sansabella* it is posterior. The former has very distinct swellings rising above hinge line, whereas in the latter, dorsal swelling, where present, is inconspicuous. Further study of additional material may indicate that the Kinkaid form is conspecific with *C. rotunda* of the Clore formation.

Genus PERPRIMITIA Croneis and Gale

Perprimitia funkhouseri Croneis and Thurman, n. sp.

Plate VII, figs. 18–19

Carapace subrectangular, elongated, small; hinge line straight, depressed anteriorly; cardinal angles obtuse; anterior and posterior outlines broadly rounded; posterior more uniformly rounded than anterior; ventral outline only slightly convex; subparallel to hinge line. Right valve larger than left and overlaps

it on free margin; overlap on posterior and venter essentially equal, anterior overlap less. Anterior of carapace marked with swelling beginning in a lobate form just posterior of mid-carapace below median line and paralleling shell margin forward and upward to terminate in a low node-like structure posterio-ventrad of anterior cardinal angle; posterior region more tumid than anterior; swelling occupies most of posterior area, terminating near posterior cardinal angle in low blunt spine extending slightly above hinge line. Between the two swollen areas lies a shallow curved sulcus with convexity posterior. Anterior of mid-carapace is located a small pit at edge of dorsal sulcus, posterio-ventrad of low node. Greatest thickness of carapace at center of posterior swelling on median line. Surface smooth.

Dimensions of type specimen: length, .58 mm.; height, .30 mm.; thickness, .26 mm.

Locality K3. Holotype, Walker Museum, No. 44504.

Remarks: *P. funkhouseri* differs from *P. spinosa* from the Golconda formation in that the former has a more elongate outline and has a venter subparallel to dorsum, whereas in the latter species the ventral and dorsal outlines form a marked angle. Posterior sulcus in *P. spinosa* is poorly developed. *P. funkhouseri* differs from *P. robusta* of the Golconda formation in that the posterior sulcus is more conspicuous and the carapace outline more elongate in the former species.

Family Kloedenellidae U. and B.

Genus JONESINA U. and B.

Jonesina (?) *tumida* Croneis and Thurman, n. sp.

Plate VII, fig. 11

Carapace subquadrate to subovate in outline, large; hinge line straight, depressed; cardinal angles obtuse; anterior cardinal angle more obtuse than posterior; anterior and posterior outlines broadly rounded; anterior ventral swing more broadly and evenly rounded than large posterior ventral swing which continues slightly ventrad of mid-ventral outline; ventral outline slightly

concave; free margin marked by low rolled ridge; ridge thickest and most noticeable on venter. Carapace convex, ornamented with three nodes or swellings; slight, barely perceptible swelling in anterio-dorsal region forms smallest of the three nodes; second node medium sized, located just posterior of first node and separated from it by a small dorsally expanding sulcus; largest node occupies complete posterior portion of carapace, being so swollen as to be almost uniformly convex; swollen area extends slightly above hinge line at mid-posterior; intermediate and posterior nodes separated by a deep subtriangular sulcus located just anterior of mid-carapace above median line, a posterio-ventrally directed prong of which partially delimits posterior swelling on its anterio-ventral sector; nodes joined together and merging into carapace swelling ventrad of median line. Carapace thickest at posterio-dorsad portion of posterior node; surface slopes abruptly to hinge line, posterior outline, and to major sulcus from this point; slope gentle along carapace toward anterior. Surface smooth.

Dimensions of type specimen: length, .90 mm.; height, .57 mm.; thickness (one valve), .30 mm.

Locality K5. Holotype, Walker Museum, No. 44505.

Remarks: Referred to *Jonesina* with considerable doubt. The specimen may be a large *Perprimitia*. It resembles *Perprimitia* in that the carapace outlines and the sulcus arrangements are similar. It differs in that its size is approximately twice as great, posterior swelling is much greater and it does not show posterior spine which is commonly seen on *Perprimitia*. *J.* (?) *tumida* is very similar to *J. howardensis* Kellett from the Howard formation, as figured in the Journal of Paleontology, Vol. 7, Plate 14, but an examination of paratype specimens shows them to be very dissimilar in that the sulcus of *J. howardensis* does not divide into a "Y" shape at its lower extremity; furthermore the posterior node of the latter species carries a small spine on its dorsal area which is not seen in *J.* (?) *tumida*. It is deemed best, however, to refer the Kinkaid specimen to *Jonesina* until more material is found.

Genus DELOIA Croneis and Thurman, n. gen.

This genus is characterized by straight hinge line, Knoxina-like outline, and serrated flanges along carapace outline. Right valve overlaps left and occupies almost if not all the area between the flanges. Sulcus anterior.

Remarks: Differs from *Knoxina* Coryell and Rogatz in that the valve flanges are serrate and the overlap is not conspicuously rolled as in *Knoxina*. In *Jonesina* Ulrich and Bassler the left valve is described as being the larger, whereas in *Deloia* the reverse is true. The genus *Deloia* also occurs in the Clore formation.

Genotype: *Deloia serrata* Croneis and Thurman, n. sp.

Deloia serrata Croneis and Thurman, n. sp.

Plate VII, figs. 7–10

Carapace subquadrate to subovate in outline, medium sized; hinge line straight to slightly convex, slightly depressed; dorsal margin consists of small ridge parallel to hinge line; cardinal angles obtuse, the anterior one being much more obtuse than the posterior which is about 100°. Posterior and anterior outlines broadly rounded, the posterior having a much longer ventral swing; ventral outline convex. Greatest thickness of carapace posterior, midway between sulcus and posterior cardinal angle; from this area surface slopes abruptly toward hinge line and posterior dorsal border; slope less steep toward venter with most gentle slope toward anterior. Shallow triangular sulcus located just anterior to vertical median line, extending from dorsal outline to a position just anterior of mid-carapace. Valves unequal, right valve larger than left and overlaps it slightly, pill box fashion along free margin; valves flanged along free margin outline, flanges being serrate; left valve serrations much better developed than those on the right valve. Area between flanges shared unequally by the valves, right valve occupying at lesat seven-eighths of the area. Surface and area between the flanges essentially smooth.

Dimensions of type specimen: length, .75 mm.; height, .44 mm.; thickness, .31 mm.

Locality K7. Holotype, Walker Museum, No. 44515.

Remarks: *D. serrata* differs from *D. sulcata* of the Clore formation in that the posterior of the latter is more abruptly rounded and shorter than that of the former. The sulcus of the former flares more broadly toward hinge line and is slightly wider than the sulcus of the latter.

Family Kirkbyidae U. and B

Genus KIRKBYA Jones

Kirkbya bifrons Croneis and Thurman, n. sp.

Plate VII, figs. 1–2

Carapace subquadrate to subovate in outline, large, equivalved; hinge long and straight, depressed; cardinal angles obtuse but only slightly greater than 90°; posterior outline more broadly round than anterior outline; venter essentially straight to slightly concave near mid point. Carapace thickest at anterio-dorsal shoulder; from this point surface slopes steeply to hinge line; slopes less steeply toward anterior outline and anterio-ventral swing; gentle slope posteriorly; anterio-dorsal shoulder well-developed, swelling extending upward slightly above hinge line; shoulder outline rounded anteriorly, paralleling venter along ventral side and merging with carapace surface at posterior. Valves bicarinate; marginal carina forms flange completely along free margin, non-reticulate; submarginal carina separated from marginal flange by three of four reticulations in ventral area. converging to marginal flange at anterior and posterior cardinal angles; submarginal flange reticulate. Conspicuous oval pit located ventrad of ventral slope of elevated portion of carapace and somewhat posterio-ventrad of mid-carapace; length of pit approximately one and a half times width; long dimension parallels hinge line. Surface of carapace and area between flanges finely reticulate; no definite reticulation pattern.

Dimensions of type specimen: length, .93 mm.; height, .54 mm.; thickness, .51 mm.

Locality K7. Holotype, Walker Museum, No. 44506.

Remarks: *K. bifrons* has an *Aparchites*-like expression along anterior dorsal outline because of its elevation above hinge line. The species resembles *K. dorsoconvexa* Geis from the Salem limestone, but differs in that it does not have the three keel structures which Geis describes for the Salem form. *K. bifrons* differs from *K. intermedia* of the Kinkaid formation in that the anterio-dorsal shoulder of the former extends well above the hinge line.

Kirkbya intermedia Croneis and Thurman, n. sp

Plate VII, fig. 3

Carapace suboblong, fairly elongate, medium sized; hinge line straight. Cardinal angles slightly obtuse, the anterior being not greatly in excess of 90°. Anterio-ventral swing less precipitous than posterio-ventral swing. Greatest thickness at anterio-dorsal shoulder. Shoulder well developed, sloping steeply toward the anterior from area of greatest thickness to area near inner margin of submarginal flange; line of abrupt slope swings sub-parallel to free margin along venter, dying out at a point about half way between the pit and the posterior ventral swing. Just inside the submarginal flange in the posterior quarter is a conspicuous swelling paralleling the posterior swing. The structure originates at the inner edge of flange and merges anteriorly into posterior extension of elevated area. Edges bordered by marginal and submarginal which are narrow and thin on the edge; flanges sub-parallel plane of junction of valves, but are more separated at venter than at extremities where they tend to converge. Conspicuous oval pit located ventrad of sharp ventral slope of elevated portion of carapace and slightly posterio-ventrad of mid-carapace; length of pit one and one half times its width; long dimension parallels hinge line. Surface and area between flanges finely reticulate, but having no readily discernible reticulation pattern.

Dimensions of type specimen: length, .83 mm.; height, .42 mm.; thickness (one valve), .38 mm.

Locality K4. Holotype, Walker Museum, No. 44507.

Remarks: *K. intermedia* closely resembles *K. punctata* Kellett from the Stanton limestone, but can be distinguished from it by the much more rounded anterior and posterior outlines of the former. *K. intermedia* has a greater convexity of ventral outline and a more pronounced backward swing; moreover the low ridge-like swelling at the posterior of the anterio-ventral elevation, which is prominent in *K. intermedia*, is not noticed on *K. punctata*. The cardinal angles of *K. intermedia* are more obtuse than those of *K. punctata*, but not as rounded as those of *Knightina minuta* Harris and Lalicker from the Fort Riley limestone.

Kirkbya symmetrica Croneis and Thurman, n. sp.

Plate VII, figs. 4–6

Carapace suboblong, equivalved, medium sized; hinge line long and straight; cardinal angles slightly obtuse, not much greater than 90°; anterior outline slightly and more broadly rounded than posterior outline; ventral margin slightly convex. Greatest thickness of carapace anterior on median line between mid-carapace and anterior outline; surface slopes steeply from area of greatest elevation to submarginal carina at anterior and anterio-ventral swings; slope gentle toward posterior. Valve contact along free margin marked by slight flange. Valves carinate; marginal carina essentially parallels free margin; submarginal carina removed from marginal carina by four rows of reticulations in ventral area; carinations converge at or near cardinal angles; carinations narrow and thin, not marked by reticulations. Surface sub-regularly marked by fine reticulations which fail to show a very definite pattern.

Dimensions of type specimen: length, .78 mm.; height, .42 mm.; thickness, . 45 mm.

Locality K7. Holotype, Walker Museum, No. 44508.

Remarks: No pit location definitely identified as such. There is a trace, however, of what may be an inconspicuous pit ventrad of mid-carapace. *K. symmetrica* is distinguishable from other

species of *Kirkbya* by its symmetrical outline. It differs from *K. punctata* Kellett of the Stanton limestone in that *K. punctata* is less rounded on venter and contains a well developed pit not seen on this Kinkaid form.

Genus AMPHISSITES Girty

Amphissites bicarinatus Croneis and Thurman, n. sp.

Plate VIII, figs. 10–12

Carapace large, equivalved; subquadrate in outline, highly convex; posterior and ventral outlines nearly equally rounded; hinge line straight, slightly depressed; dorsal margin also straight; cardinal angles very obtuse; swings to venter broadly rounded; ventral outline slightly convex. Free edge of valves carinate; marginal carina small; submarginal carina beginning at anterio-dorsal swing of marginal carina, diverging rapidly to point opposite anterio-ventral swing, then gradually converging toward marginal carina posteriorly, dying out at posterior dorsal swing. Thickest portion of shell in subcentral area; surface slopes gently to anterio-dorsal shoulder; more steeply posteriorly; slope toward venter is abrupt ventrad of mid-carapace. Small oval pit ventrad of mid-carapace, near base of steepest portion of carapace; long dimension of pit essentially parallel hinge line. Surface and intercarinate portions finely reticulate, with rows of reticulations subparallel free edge of carapace.

Dimensions of type specimen: length, .75 mm.; height, .42 mm.; thickness, .47 mm.

Locality K6. Holotype, Walker Museum, No. 44509.

Remarks: This species similar to *A. warei* Morey, from the Amsden formation, but can be distinguished from it on the basis of several criteria. In *A. bicarinatus* the reticulations extend from swollen area of carapace to the hinge line, whereas in *A. warei* Morey the hinge is "bordered by a wide smooth border on each valve." (Morey, 1935). The dorsal outline of *A. warei* is wedge-shaped, differing from the subelliptical outline of the Kinkaid species.

Amphissites biforatus Croneis and Thurman, n. sp.

Plate VIII, fig. 9

Carapace subquadrate to subovate in outline, medium sized; hinge line slightly concave. Cardinal angles obtuse; anterior outline more evenly rounded than posterior, which tends toward angularity just ventrad of cardinal angle; ventral margin nearly straight. Free margin bordered by small ridge paralleling margin and forming its inner portion. Surface marked by three nodes; anterior node originates near median line, swelling upward gradually and terminating just above dorsal margin; posterior node not so outstanding; made up of long ridge like structure beginning posterio-ventrad of central node, paralleling posterior outline and ending at dorsal margin, just anterior to posterior cardinal angle; central node largest of the three, hemispherical. Inconspicuous oval pit located at base of central node, anterio-ventral of its mid-point; long dimension of pit directed toward anterior cardinal angle; small pit or scar marking located at posterio-ventrad portion of base of central node. Surface marked with fine reticulations arranged concentrically, sub-paralleling free edge of carapace.

Dimensions of type specimen: length, .69 mm.; height, .39 mm.; thickness (one valve), .15 mm.

Locality K2. Holotype, Walker Museum, No. 44510.

Remarks: *A. biforatus* differs from *A. fossilis*, also of the Kinkaid formation, in that the central node is relatively smaller, the rolled outline along venter is more conspicuous, and a pit or small scar marking is seen at posterio-ventral base of central node in the former species.

Amphissites fossilis Croneis and Thurman, n. sp.

Plate VIII, fig. 18

Carapace large, subquadrate to subovate in outline; hinge line straight, depressed; cardinal angles sub-equally obtuse; posterior and anterior outlines broadly rounded; anterior outline somewhat

more broadly rounded than posterior, ventral margin only very slightly convex; carapace outline has a slight backward swing. Surface marked by three nodes; posterior node, smallest of the three, consists of a low broad ridge beginning just anterior of posterio-ventral swing, parallels posterior swing and terminates at dorsal margin just anterior of posterior cardinal angle; anterior node originates just anterior of mid-venter, parallels anterior swing and terminates in a shoulder-like structure rising slightly above hinge line posterior of anterior cardinal angle; central node, most conspicuous feature of carapace, consists of large strong door knob-like swelling whose center is posterior of mid-carapace and somewhat above median line; node surrounded by moat-like depression on anterior and posterior sides. Kirbyan pit located on anterio-ventral base of central node; length of pit approximately twice its width; long dimension trends toward anterior cardinal angle. Carapace flattened on venter, falling vertically from rolled outline to free margin. Thickest portion of carapace anterio-dorsal at shoulder. Surface finely reticulate; rolled edge marked by larger reticulations than remainder of carapace; smallest reticulations on surface of central node.

Dimensions of type specimen: length, 1.00 mm.; height, .57 mm.; thickness (one valve), .36 mm.

Locality K2. Holotype, Walker Museum, No. 44511.

Remarks: *A. fossulus* is like a larger and older individual of *A. biforatus* of the Kinkaid formation but is probably a different species due to the following differences. In the former, the outside slopes of anterior and posterior nodes are more steeply sloped than on the latter. The central node of the former is relatively larger than the central node of the latter. Central portion of carapace is relatively more flattened on *A. biforatus*. *A. fossilis* differs from *A. sublineatus*, also of the Kinkaid formation, in that the reticulations are better defined, the pit is larger and more conspicuous, and the anterio-ventral portion of the flange flares broadly in the latter species. *A. fossilis* can be distinguished from *A. rothi* of the Clore formation in that the latter has a distinct ridge along the ventral outline.

Amphissites insignis Croneis and Thurman, n. sp.

Plate VIII, figs. 13–15

Carapace subquadrate, equivalved, large; hinge line straight and slightly depressed; dorsal margin straight; cardinal angles obtuse, posterior being more obtuse than anterior; anterior and posterior swings to venter well rounded; ventral outline slightly convex. Free portions of valves carinate; submarginal carina broad and thin; separated from marginal carina by an area marked by three or four reticulations, subparallel to marginal carina along venter; the two carina converging at posterior and anterior dorsal swings not far below apex of cardinal angles. Dorsad of the submarginal carina and essentially paralleling it in posterior and ventral areas is a thin, narrow ridge, terminating at or near dorsal margin; ridge forms broad "U", whose base parallels the ventral swing; anterior arm of "U" farther from submarginal carina and shorter than posterior arm. Thin, narrow, sublongitudinal rib enclosed within and cut off by the "U." This rib originates on the anterior arm of the "U" near center of anterior half of carapace, and slants upward to a point just dorsad of center of large hemispherical node, thence downward to terminate against posterior ventral swing of "U"; trace of a small, short horizontal flange just dorsad of mid-carapace. Strong hemispherical node just ventro-posterior of mid-carapace. Large oval pit located at anterio-ventral base of node; long diameter parallels a diagonal line from anterior cardinal angle to posterior ventral swing. Thickest portion of shell in anterio-dorsal quarter, near point of termination of anterior arm of "U." Surface finely reticulate.

Dimensions of type specimen: length, 1.05 mm.; height, .60 mm.; thickness, .59 mm.

Locality K4. Holotype, Walker Museum, No. 44512.

Remarks: *A. insignis* somewhat resembles *A. centronotus* (Ulrich and Bassler) from which it may be differentiated by arrangement of flanges on carapace. The anterior and posterior nodes seen in *A. centronotus* (Ulrich and Bassler) are in *A. insignis* united ventrally to form a broad "U" shaped flange.

Uniting the two arms of the flange is another curved flange with its convexity toward the dorsal edge. These additional flanges are not seen in other species of Amphissites. *A. insignis* resembles *A. dattonensis* Harlton from the Pennsylvanian, but can be distinguished by the transverse flange and the rounded central node of the former.

Amphissites sublineatus Croneis and Thurman, n. sp.

Plate VIII, fig. 16

Carapace subquadrate in outline, elongate, large; hinge line straight, depressed; cardinal angles obtuse, anterior being more obtuse than posterior, posterior about 130°; dorsal outline concave; anterior and posterior outlines well rounded, anterior being the more rounded; ventral outline straight and subparallel to hinge line. Greatest height anterior, just posterior of anterior cardinal angle at position occupied by anterior node. Surface ornamented by three conspicuous nodes, posterior one of which is smallest; posterior node originates slightly anterior of termination of posterio-ventral swing and just above median line, terminates slightly above hinge line; swelling of the node merges gradually into carapace surface; anterior node much larger than posterior; located slightly posterior of anterior cardinal angle, and has steeply sloping sides, extending prominently above hinge line; central node, which is most conspicuous feature of carapace, is a large globular swelling whose center is slightly above median line and somewhat posterior of mid-carapace; central node separated from anterior and posterior nodes by deep, dorsally expanding grooves. Large suboval pit located at anterio-ventral base of central node; length of pit approximately one and one half times its width; long line of pit directed toward the anterior cardinal angle. Free edges of valves flanged; submarginal flange begins just above median line on anterior outline, diverges rapidly from marginal flange, parallels it along venter, converging again toward marginal flange and dying out just ventrad of posterior cardinal angle; at anterior ventral swing the submarginal flange and adjacent portion of carapace flares con-

spicuously outward from main body of carapace. Submarginal flange marked by a row of reticulations along inner margin; remainder of surface and area between flanges marked by much finer reticulations without any very definite pattern, but anterior node is apparently longitudinally striate.

Dimensions of type specimen: length, 1.10 mm.; height, .60 mm.; thickness (one valve), .27 mm.

Locality K1. Holotype, Walker Museum, No. 44513.

Remarks: *A. sublineatus* resembles *A. ciscoensis* Harlton from the Pennsylvanian, but the two species can be distinguished by the larger nodes and much finer reticulations of the former. *A. sublineatus* differs from *A. centronotus* Ulrich and Bassler, from the upper Fort Scott limestone, in that the former has small flange like structures in place of the larger anterior and posterior nodes seen on the latter.

Genus BALANTOIDES Morey

Balantoides reticulatus Croneis and Thurman, n. sp.

Plate VIII, fig. 17

Carapace subquadrate to subsemicircular in outline, small; hinge line straight, depressed; cardinal angles obtuse, but only slightly greater than 90°; anterior cardinal angle less obtuse than posterior; anterior and posterior ventral swings broadly and subequally rounded; ventral outline broadly rounded. Valve marked by three prominent nodes; anterior node is termination of small ridge which begins posterior of mid-point of ventral outline, and essentially parallels carapace outline to termination slightly above anterior cardinal angle; central node, largest of the three, originates dorsad of mid-carapace and extends prominently above hinge line; posterior node originates just dorsad of horizontal median line and anterior of the posterior margin, terminating at dorsal outline. Greatest thickness of shell in area of base of posterior node; from this area surface slopes somewhat steeply to posterior and posterio-ventral swings, with less steep slopes toward anterior. Posterio-ventral quarter marked by slight tumidity of carapace surface; just below cardinal

angles the carapace borders are very precipitate, approaching 90° at anterior. Nodes and surface marked by fine reticulations having no very definite arrangement.

Dimensions of type specimen: length, .57 mm.; height, .36 mm.; thickness (one valve), .18 mm.

Locality K3. Holotype, Walker Museum, No. 44514.

Remarks: *B. reticulatus* differs from *B. quadrilobatus* Morey from the Amsden formation in that the nodes of the former are more distinctly formed and rise more conspicuously above the hinge line. *B. reticulatus* differs from *B. moreyi* of the Clore formation in that the central node is more sharply formed and extends higher above hinge line. The former also has a low ridge like structure forming the ventral outline and joining the anterior node. This feature is not seen on *B. moreyi.*

Family Glyptopleuridae Girty

Genus GLYPTOPLEURA Girty

Glyptopleura adunca Croneis and Thurman, n. sp.

Plate VIII, fig. 3

Carapace subquadrate to subovate in outline, medium sized; hinge line straight, depressed; cardinal angles obtuse; anterior cardinal angle less rounded than posterior angle; anterior and posterior outlines broadly rounded, posterior ventral slope longer and less well rounded than anterior ventral swing; ventral outline essentially straight and sub-parallel hinge line; highest point of carapace posterior to mid-line. Surface marked by strong sub-parallel ribs, which trend slightly upward from anterior to posterior. Ventral and dorsal margins flanged. First rib ventrad of dorsal margin depressed near mid-point to form a pit like sulcus; this broken rib and first rib dorsad of ventral flange form a broad "U" whose base is anterior and essentially parallels the anterior outline; second rib ventrad of dorsal flange and second major rib dorsad of ventral flange form a less broad "U" whose base forms a part of base of larger "U"; between first and second major ribs dorsad of ventral flange is the trace of a small short rib apparently splitting off from next major rib above,

located chiefly but not wholly in anterior half of carapace; implated within the smaller "U" are three strong ribs, dorsal one of which is broken at pit location; the midrib joins the dorsal one at anterior and posterior to form peculiar hook-like terminations; the ventrad of the three ribs is shorter than the next above; enclosed ribs show a slight convexity toward the dorsal margin. All ribs terminate posteriorly short of the posterior swing leaving a small border of the carapace unribbed. Between the dorsal arm of inner "U" and the central one of the enclosed ribs is located a large subcircular pit just dorsad of mid-carapace.

Dimensions of the type specimen: length, 1.05 mm.; height, .62 mm.; thickness, .52 mm.

Locality K3. Holotype, Walker Museum, No. 44516.

Remarks: *G. adunca* is similar to *G. pseudosulcata* but can be distinguished from it in that the former has three major ribs enclosed within the smaller "U," whereas the latter carries only two. The up-curving of the enclosed ribs, plus the uniting of the anterior and posterior terminations of the upper two ribs to form hook-like structures serve to delineate *G. adunca* from other species of *Glyptopleura*. Dark mark in lower mid-carapace is break in shell.

The orientation of all species of *Glyptopleura* in this study, is given as described by Geis in the Journal of Paleontology, vol. 6, No. 2, pp. 151–152.

Glyptopleura compta Croneis and Thurman, n. sp.

Plate VIII, fig. 4

Carapace subquadrate to subovate in outline, large; hinge line straight, slightly depressed; cardinal angles obtuse; posterior angle less obtuse than anterior; posterior ventral swing longer and more broadly rounded into venter than anterior swing; ventral outline essentially straight; venter and upper half of valves carinate; greatest shell height posterior to mid-line. Surface marked with subparallel ribs, which trend diagonally upward from anterior to posterior. Dorsal rib broken near mid-point to form shallow pseudo-sulcus. Dorsal and ventral ribs form a

broad "U", whose base lies anterior and essentially parallels the anterior outline; enclosed within the large "U" is a smaller "U", whose prominent arms are composed of the first rib ventrad of dorsal rib and first rib dorsad of ventral rib, the bases of the two "U's" coinciding; located within the smaller "U" are three prominent ribs, dorsad one of which is broken for pit location; anterior portion of this upper rib is independent; middle rib of the three unites with posterior termination of the rib just dorsad, and with the anterior termination of the rib just ventrad to form a much flattened "Z" shaped structure; posterior termination of other ribs tends to parallel posterior swing; ribs terminate just short of posterior outline, leaving small portion of carapace free of ornamentation. Medium sized pit located anterio-dorsad of mid-carapace between second and fourth ribs ventrad of dorsal flange, bisects third rib ventrad. Greatest thickness of carapace posterior, on median line near termination of ribs. Surface slope from this point abruptly to posterior; slopes more gentle toward dorsum and venter, with very gradual slope posterior toward base of "U".

Dimensions of type specimen: length, 1.09 mm.: height, .66 mm.; thickness, .57 mm.

Locality K2. Holotype, Walker Museum, No. 44517.

Remarks: *G. compta* may be distinguished from other species of *Glyptopleura* by the arrangement of the ribs inside the smaller "U". The central one of these ribs is joined at the posterior to the next rib dorsad and at the anterior to the next rib ventrad. *G. compta* can be distinguished from *G. symmetrica* of the Clore formation in that the latter has the three ribs enclosed in the smaller "U" uniting at the anterior to form a third "U" whose base is slightly posterior to base of larger "U's".

Glyptopleura kellettae Croneis and Thurman, n. sp.

Plate VIII, fig. 8

Carapace subquadrate to subovate in outline, medium sized; hinge line straight, depressed; cardinal angles obtuse; posterior cardinal angle more rounded than anterior cardinal angle;

anterio-ventral swing more broadly rounded than posterior swing; venter almost straight, tending slightly toward concavity toward mid-point, flanged; dorsal margin nearly straight or slightly concave, parallel hinge line, flanged. Surface marked by strong sub-parallel ribs essentially horizontal, paralleling dorsal margin; dorsal rib depressed at mid-point to form a pseudo-sulcus; dorsal and ventral ribs form a broad "U" whose base is anterior and essentially parallels anterior outline; second rib dorsad of ventral flange low, short, and broad; third rib dorsad of venter and second rib ventrad of dorsal flange form a less broad but very prominent "U" enclosed within the larger "U", the base of the two structures coinciding; implanted within the smaller "U" are two strong independent ribs, dorsad of which is the longer and hooks sharply downward at anterior termination; the ventrad of the independent ribs somewhat shorter and much less prominent than the dorsal one; posterior rib terminations, especially of the two "U's", curved in rough parallelism to posterior swing; ribs terminate short of posterior outline leaving small area of carapace unribbed. Medium sized circular pit located near mid-carapace between dorsad arm of smaller "U" and enclosed dorsad independent rib. Carapace comparatively thin; thickest portion located posterior; surface slopes gently in all directions from point of greatest thickness; no abrupt changes of elevation.

Dimensions of type specimen: length, .88 mm.; height, .47 mm.; thickness, .36 mm.

Locality K3. Holotype, Walker Museum, No. 44518.

Remarks: *G. kellettae* is distinguished from other *Glyptopleura* species by the parallelism of its dorsal and ventral outlines and the ribs. It may be distinguished from *G. intermedia* of the Golconda formation by the increased height of the latter near the anterior cardinal angle. *G. kellettae* differs from *G. pseudosulcata*, also of the Kinkaid formation, in not having a pronounced angularity on the posterior outline.

Glyptopleura pseudosulcata Croneis and Thurman, n. sp.

Plate VIII, fig. 7

Carapace subquadrate to subovate in outline, large; hinge line straight; anterior cardinal angle somewhat more pronounced

than posterior; anterior ventral swing slightly more precipitous than the much longer posterior ventral swing, but the two joining the nearly straight venter with subequal angulation. Surface marked with strong subparallel ribs, which trend diagonally upward from anterior to posterior. Dorsal rib and ventral rib form a broad "U", whose base is anterior and parallels the anterior outline. Dorsal rib broken near mid-point to form a pseudo-sulcus. First rib ventrad of dorsal arm and first rib dorsad of ventral arm form a less broad "U", whose base forms a portion of the base of the larger "U". Implated in the smaller "U" are two strong, independent ribs, of which the dorsal is the longer. A minor independent rib lies in posterior region between first rib ventrad of the dorsal rib and the dorsal independent rib. The ventrad of the two independent ribs essentially straight; other ribs are curved near ends in rough parallelism to curvature of posterior shell outline; small area along posterior outline unribbed. Slight swelling in posterio-dorsal quarter. Anterio-dorsad of center of carapace is a small circular pit, which lies between the dorsal arm of the smaller "U" and the upper major independent rib. Dorsal and ventral edges of carapace flanged; ventral flange joins the "U" at the anterior ventral swing.

Dimensions of the type specimen: length, .94 mm.; height, .54 mm.; thickness, .48 mm.

Locality K4. Holotype, Walker Museum, No. 44519.

Remarks: *G. pseudosulcata* differs from other species of *Glyptopleura* in having an elongated posterio-ventral swing extending above median line giving rise to a marked angularity of the posterior outline. It can be distinguished from *G. similis* from the Clore formation in that the latter has three strong ribs implanted within the smaller "U", the dorsal one of which is much stronger than the corresponding rib in *G. pseudosulcata*.

Glyptopleura reniformis Croneis and Thurman, n. sp.

Plate VIII, figs. 1–2

Carapace subquadrate to subovate in outline, large; hinge line slightly concave, with higher portion posterior; anterior cardinal

angle less obtuse than posterior; anterior ventral swing much more precipitous than posterior ventral swing. Surface marked with prominent sub-parallel ribs, which trend diagonally upward from anterior to posterior. Dorsal rib and first major ventral rib form a broad "U" whose base is essentially parallel to the anterior outline. Dorsal rib is broken at its mid-point to form a pseudo-sulcus. A short, minor ventral rib joins the "U" at the anterior ventral swing. The second major rib dorsad of the ventral minor one, and the first major rib ventrad of the broken dorsal one form a less broad "U", whose base is a portion of the base of the larger "U"; right valve shows a trace of small short rib posterior of mid-carapace between the ventral arms of the two "U's". Enclosed within the smaller "U" are two strong independent ribs. First and second major ribs ventrad of the broken dorsal one nearly or completely joined at the posterior, to form a "V" like structure. All other ribs terminate at the posterior, short of the posterior swing. All ribs ventrad of the center point swing slightly upward near their posterior termination, so that the ends tend to parallel the posterior swing. The ribs dorsad of the center point swing downward near their posterior termination. The dorsal portion of the carapace has a flange or ridge just ventrad of the hinge line. A small circular pit is located dorsad of the center point, just ventrad of the upper arm of the smaller "U".

Dimensions of the type specimen: length, 1.08 mm.; height, .69 mm.; thickness, .66 mm.

Locality K4. Holotype, Walker Museum, No. 44520.

Remarks: *G. reniformis* may be distinguished from other species of *Glyptopleura* by the almost or complete joining at the posterior of its first and second major ribs ventrad of the broken dorsal one. It may be distinguished from *G. alternata* of the Clore formation, and *G. decacostata* of the Golconda formation, by the absence of the alternating strong and weak ribs that characterize the two last named species. It differs from *G. compta*, of the Kinkaid formation, in that the latter has three strong ribs implated within the "U".

Glyptopleura teretiformis Croneis and Thurman, n. sp.

Plate VIII, fig. 5

Carapace outline subquadrate to subovate, elongate, medium sized; hinge line nearly straight, depressed slightly; cardinal angles obtuse, anterior angle being less obtuse than posterior; anterior and posterior outlines broadly rounded; anterior ventral swing more evenly rounded and not so long as posterior ventral swing; ventral outline straight and roughly parallel to dorsal margin. Surface marked with subparallel ribs trending slightly upward from anterior to posterior. Dorsal margin flanged; ventral margin less strongly flanged. First rib ventrad of dorsal margin broken to form a pseudo-sulcus just anterior to a vertical median line; broken rib and first rib dorsad of ventral flange unite anteriorly to form a broad "U" whose base parallels anterio-ventral swing; second rib ventrad of dorsal margin and second rib dorsad of ventral margin form a smaller "U", whose base is a portion of the base of the larger "U"; implanted within the smaller "U" are two ribs, which unite posteriorly to form a thin "U" whose base is posterior and whose ventral arm is shorter than the dorsal one; other rib terminations tend to parallel posterior swing. Between dorsal arm of smaller "U", whose base is anterior, and dorsal arm of smallest "U", whose base is posterior, is located a small pit just anterio-dorsal of mid-carapace. Thickest portion of carapace posterior, with abrupt slope to posterior margin; other slopes more gentle, with most gentle slope anterior.

Dimensions of type specimen: length, 1.00 mm.; height, .54 mm.; thickness, .50 mm.

Locality K6. Holotype, Walker Museum, No. 44521.

Remarks: *G. teretiformis* is distinguishable from other species of *Glyptopleura* due to the joining at the posterior of the two ribs enclosed within its smaller "U". Carapace elongation and long posterio-ventral swing are also typical of the species. *G. teretiformis* somewhat resembles *G. reniformis* from the Kinkaid formation, but can be differentiated by the dorsal arm of the

"U", whose base lies posterior. In the latter species this arm joins the dorsal arm of the smaller "U", whose base lies anterior.

Glyptopleura varicostata Croneis and Thurman, n. sp.

Plate VIII, fig. 6

Carapace subquadrate to subovate in outline, large; hinge line straight, depressed; dorsal margin slightly concave, flanged; cardinal angles obtuse; anterior cardinal angle less obtuse than posterior; anterior outline more evenly rounded than posterior outline, which is slightly angular above mid-height; anterior ventral swing more evenly rounded than posterior ventral swing. Surface marked by strong sub-parallel ribs which trend upward from anterior to posterior terminations, which fail to reach posterior outline of carapace; first rib dorsad of ventral edge moderately short, free; first rib ventrad of dorsal flange broken near mid-point to form a pseudo-sulcus; broken dorsal rib and second rib dorsad of venter form a broad "U" whose base lies along anterior margin; between ventrad arm of "U" and next complete rib above lies a short low rib, whose length is approximately one-third that of a major rib; second rib ventrad of dorsal flange and first rib dorsad of short rib form a less groad but strongly marked "U" enclosed within the larger "U", the bases of the two "U's" coinciding; enclosed within the smaller "U" are three strong independent ribs, the dorsad of which is broken by the pit leaving both ends short and free; central rib of the three is long and essentially straight except at the anterior where rib turns sharply downward in a claw-like termination; ventrad rib of the three relatively straight and somewhat shorter than the rib next above; posterior ridge terminations roughly parallel posterior shell outline; terminations fall short of posterior shell outline, leaving a slight area on posterior of carapace free of ornamentation. Large circular pit located anterio-dorsad of mid-carapace just ventrad of dorsal arm of smaller "U". Thickest part of carapace mid-posterior near termination of ribs; surface slopes abruptly to posterior outline from this point;

less abruptly from venter and dorsum; slope to anterior very gentle.

Dimensions of type specimen: length, 1.09 mm.; height, .66 mm.; thickness, .56 mm.

Locality K1. Holotype, Walker Museum, No. 44522.

Remarks: *G. varicostata* is notable for its heavy, close set ribs, strong dorsal flange, and the strongly hooked anterior end of the center one of the three enclosed ribs. It differs from *G. compta*, of the Kinkaid formation, in that the latter has the central rib of the three enclosed ones united with posterior of next rib dorsad and anterior of next rib ventrad. *G. varicostata* may be distinguished from *G. alata*, of the Clore formation, in that the latter has the anterior ends of the center and ventral ribs of the three enclosed ones united at their posterior terminations.

Family Bairdiidae Lienenklaus

Genus BAIRDIA McCoy

Bairdia galei Croneis and Thurman, n. sp.

Plate VII, fig. 21

Carapace subelliptical in outline, elongate, medium sized. Anterio-dorsal slope straight or slightly convex near mid-dorsum to slightly concave near anterior cardinal angle; posterior dorsal slope convex excepting toward posterior, where curvature reverses to form a short beak; anterio-ventral and posterio-ventral swings convex, the former with much greater length than the latter; ventral outline slightly concave anterior of mid-point; sharp indentations of free margins at point of ventral concavity, with effect most noticeable on right valve. Left valve larger than right and completely overlaps it with possible exception of small areas along ventral edges of both beaks; greatest amount of overlap on upper portion of carapace; below median line overlap less conspicuous. Short stubby beak located just ventrad of mid-height at posterior termination; carapace outline shows sharp angularity above median line at anterior beak. Thickest point of shell near mid-carapace; from this point surface slopes

gradually and evenly to hingement area and free margins. Surface smooth or very slightly roughened.

Dimensions of type specimen: length, 1.02 mm.; height, .48 mm.; thickness, .37 mm.

Locality K6. Holotype, Walker Museum, No. 44523.

Remarks: This species is distinguished on the basis of the disproportionately large left valve whose ventral overlap hooks upward and over right valve in mid-ventral area. *B. galei* differs from *B. cooperi*, of the Golconda formation, in that the former is more elongate, and has an anterior beak not seen on the latter.

Genus BAIRDIOLITES Croneis and Gale

Bairdiolites brevirostris Croneis and Thurman, n. sp.

Plate VII, fig. 20

Carapace subrhomboidal to suboblong, medium sized; left valve overlaps right completely, except on a small area at posterio-ventral portion of beak, greatest area of overlap dorsal. Hinge line convex. Dorsal outline of left valve angular; right valve dorsal outline much more evenly rounded; anterio-dorsal outline sharply rounded on left valve; anterio-dorsal outline of right valve more angular; posterio-dorsal outline of left valve broadly rounded, reversing curvature in posterior just below mid-carapace line to form short beak; right valve curvature parallels left valve outline, but outline much more abruptly rounded in posterio-dorsal area; overlap slight along venter, where valve outlines are essentially parallel, with slight concavity near mid-venter; anterio-ventral swing smoothly rounded with overlap approximately same amount as ventral overlap. Thickest portion of shell posterio-central along median line; surface slopes steeply toward dorsum and venter from this area; slope less steeply toward posterior; very gentle slope toward anterior. Surface smooth, except where marked by two crescentiform ridges; posterior ridge located just behind center of posterior half of carapace, with concavity anterior; forward ridge located behind center of anterior half of carapace, with concavity posterior.

Dimensions of type specimen: length, .81 mm.; height, .51 mm.; thickness, .30 mm.

Locality K9. Holotype, Walker Museum, No. 44524.

Remarks: *B. brevirostris* can be distinguished by the shortness of the posterior beak and pronounced angularity on dorsum left valve. *B. brevirostris* differs from *B. crescentis* of the Golconda formation in that the latter does not have as much overlap along dorsum and does not have the pronounced dorsal angularity of left valve that is seen on the former. *B. brevirostris* differs from *B. elongatus* of the Clore formation in that the former is not as elongate, and shows an angularity on dorsal outline of left valve which is not seen on the latter.

Family Cytherellidae Sars

Genus CAVELLINA Coryell

Cavellina mediocris Croneis and Thurman, n. sp.

Plate VII, fig. 17

Carapace medium sized, subreniform, inequivalved; dorsal margin arched, greatest height near the middle; posterior and anterior swings broad, the anterior being more evenly rounded; posterior outline tends toward angularity immediately above median line at posterior dorsal swing; ventral outline essentially straight. Dorsal view wedge shaped; greatest thickness near posterior; from point of greatest thickness, surface slopes abruptly to posterior valve margin; slopes dorsad and ventrad not as steep; very gentle slope toward anterior. Right valve larger than left and overlaps it completely except at anterior swing; left valve outline follows closely that of right valve excepting it shows less angularity at posterior dorsal swing, and tends slightly toward concavity at mid-venter; greatest amount of overlap along dorsal swing; overlap along venter somewhat less than along dorsal edge, but slightly greater than overlap along posterior swing; overlap ends abruptly at anterior of ventral swing and at mid-anterio-dorsal swing, leaving anterior of valves free; anterior edge of left valve appears to lie on flattened portion of right valve leaving a small rim of right valve protruding anteriorly. Surface smooth.

Dimensions of type specimen: length, .94 mm.; height, .60 mm.; thickness, .43 mm.

Locality K3. Holotype, Walker Museum, No. 44525.

Remarks: *C. mediocris* closely resembles *C. glandella* (Whitfield) from the Salem formation, but can be differentiated since the latter shows a vertical shallow furrow just anterior of the area of maximum thickness. This feature is not seen in *C. mediocris*. *C. mediocris* differs from *C. ovalis* of the Clore formation, in that the latter shows a slightly larger overlap on dorsal and ventral swings, but does not have the slight concavity at mid-venter of the right valve.

Genus SULCELLA Coryell and Sample

Sulcella crassimarginata Croneis and Thurman, n. sp.

Plate VII, figs. 15–16

Carapace subovate in outline, medium sized. Hinge line essentially straight to convex; right valve dorsal outline arched; anterior and posterior outlines broadly rounded, posterior outline being the more evenly rounded; ventral outline slightly convex. Right valve larger than left and overlaps it completely. Greatest overlap dorsal where right valve outline is arched considerably above hingement; venter shows next smaller overlap; the overlap at the anterior outline is intermediate between that shown on venter and at posterior where smallest amount is seen. Left valve outline follows closely that of right valve excepting at dorsal position where it is essentially straight instead of broadly arched. Greatest height just anterior of vertical median line at point of greatest dorsal convexity. Thickest portion of carapace posterior, on median line midway between pit and carapace outline; from this point surface slopes roundly, with greatest convexity toward the posterior, and the most gentle slopes toward the anterior. Shallow triangular sulcus located immediately anterior of vertical median line; base of sub-triangular sulcus located at hinge line; sulcus ends in a deep pit just anteriodorsad of mid-carapace. Surface smooth.

Dimensions of type specimen: length, .93 mm.; height, .60 mm.; thickness, .42 mm.

Locality K5. Holotype, Walker Museum, No. 44526.

Remarks: *S. crassimarginata* resembles *S. warthini* Coryell and Sample from the Mineral Wells formation, but the two can be distinguished since the overlap is greater on the former, and its sulcus is located anterior of vertical median line, whereas the sulcus is located posterior of median line on the latter species.

KINKAID LOCALITY INDEX (ILLINOIS)

Notations, This Paper	*Illinois Geological Survey Register Notations*		*Geographic Locations*
Locality K1	0419.50	P55 (4¼)	Kinkaid limestone and shale in railroad cut 3 miles east of Simpson, Pope County
Locality K2	0419.91	P56 (A)	Kinkaid shale outcrop, 10 feet thick, in road ½ mile southeast of Robbs, Pope County. Fossiliferous shale at top
Locality K3	0428.75	P51 B	Kinkaid limestone, coal, fossiliferous shale, and sandstone in draw ¾ mile southeast of Glendale, Pope County
Locality K4	0520.76	P65 A	Kinkaid fossiliferous, yellow shale with white calcareous nodules, in road ½ mile south of Veach School, Johnson County
Locality K5	0521.47	P65 T	Kinkaid limestone and shale in ravine 1 mile northwest of Bloomfield, Johnson County
Locality K6	0523.11	P69 (A)	Kinkaid fossiliferous gray clay shale along road 1¼ miles east of Bloomfield, Johnson County
Locality K7	0524.0(?)	P71 (A)	Kinkaid yellow shale soft, sticky, and fossiliferous, ¼ mile east of old Whiteside School, Johnson County
Locality K8	0524.84	P70 3	Kinkaid formation in creek ¾ mile northeast Whiteside School, Johnson County
Locality K9	0535.SW4	P39 H	Kinkaid formation, presumably in SW ¼ Sec. 35, about 2 miles southeast of Bloomfield, Johnson County

BIBLIOGRAPHY

BASSLER, R. S., AND KELLETT, BETTY, "Bibliographic Index of Paleozoic Ostracoda," *Geological Society of America, Special Papers*, No. 1, 1934.

This index is arranged by periods and formations as well as by species. All references to ostracode papers published prior to January 1, 1934 are included in it.

COOPER, C. L., "Ammonium Chloride Sublimate Apparatus," *Journal of Paleontology*, Vol. 9 (1935), No. 4, pp. 357–359.

CORYELL, H. N., AND WILLIAMSON, MARJORIE, "Ostracode Fauna of the Waldron Shale," *American Museum of Natural History*, No. 870, (1936) pp. 1–7.

CRONEIS, CAREY, AND GALE, ARTHUR S., JR., "New Ostracodes from the Golconda Formation," Den. Univ. Bull., Jour. Sci. Lab., Vol. XXXIII, Dec. 1938.

CRONEIS, CAREY, AND FUNKHOUSER, HAROLD, "New Ostracodes from the Clore Formation," Den. Univ. Bull., Jour. Sci. Lab., Vol. XXXIII, Dec. 1938.

GARDNER, JULIA, "Kincaid Formation, New Name Proposed for Lower Midway of Texas," *Bulletin of The American Association of Petroleum Geologists*, Vol. 17 (1933), No. 6, p. 744.

GEIS, H. L., *Journal of Paleontology*, Vol. 6, No. 2 (1932), pp. 150–55.

HARRIS, R. W., AND WORRELL, FRANK, "A Fossiliferous Horizon from the Lower Permian of Caddo County, Oklahoma," *Journal of Paleontology*, Vol. 10 (1936), No. 6, pp. 518–519.

KELLETT, BETTY, "Ostracodes of the Upper Pennsylvanian and the Lower Permian of Kansas," *Journal of Paleontology*, Vol. 9 (1935), No. 2, pp. 132–166.

———, "Carboniferous Ostracodes," *Journal of Paleontology*, Vol. 10 (1936), No. 8, pp. 760–784.

MOREY, P. S., "Mississippian Ostracoda from Missouri," *Journal of Paleontology*, Vol. 9 (1935), No. 4, pp. 316–326.

———, "Ostracoda from the Amsden Formation of Wyoming," *Journal of Paleontology*, Vol. 9 (1935), No. 6, pp. 474–482.

———, "Ostracoda from the Chouteau Formation of Missouri," *Journal of Paleontology*, Vol. 10 (1936), No. 2, pp. 114–122.

PAYNE, K. A., "Pennsylvanian Ostracoda from Sullivan County, Indiana," Journal of Paleontology, Vol. 11 (1937), No. 4, pp. 276–288.

WELLER, STUART, "Geology of Hardin County," *Illinois State Geological Survey*, Bulletin 41 (1920), pp. 212–225.

PLATES

EXPLANATION OF PLATE VII

(All figures are of holotypes; magnifications are approximations accurate to within 4 percent.)

Figs. 1–2. *Kirkbya bifrons* Croneis and Thurman, n. sp.; fig. 1, left valve, ×35; fig. 2, dorsal view, ×35.

Fig. 3. *Kirkbya intermedia* Croneis and Thurman, n. sp.; right valve, ×35.

Figs. 4–6. *Kirkbya symmetrica* Croneis and Thurman, n. sp.; fig. 4, left valve, ×40; fig. 5, ventral view, ×40; fig. 6, dorsal view, ×40.

Figs. 7–10. *Deloia serrata* Croneis and Thurman, n. gen., n. sp.; fig. 7, left valve, ×40; fig. 8, ventral view, ×40; fig. 9, dorsal view, ×40; fig. 10, right valve, ×40.

Fig. 11. *Jonesina ? tumida* Croneis and Thurman, n. sp.; right valve, ×35.

Fig. 12. *Pseudoparaparchites aclis* Croneis and Thurman, n. sp.; right valve, ×50.

Figs. 13–14. *Sansabella laevis* Croneis and Thurman, n. sp.; fig. 13, dorsal view, ×35; fig. 14, left valve, ×35.

Figs. 15–16. *Sulcella crassimarginata* Croneis and Thurman, n. sp.; fig. 15, left valve, ×35; fig. 16, dorsal view, ×35.

Fig. 17. *Cavellina mediocris* Croneis and Thurman, n. sp.; left valve, ×35.

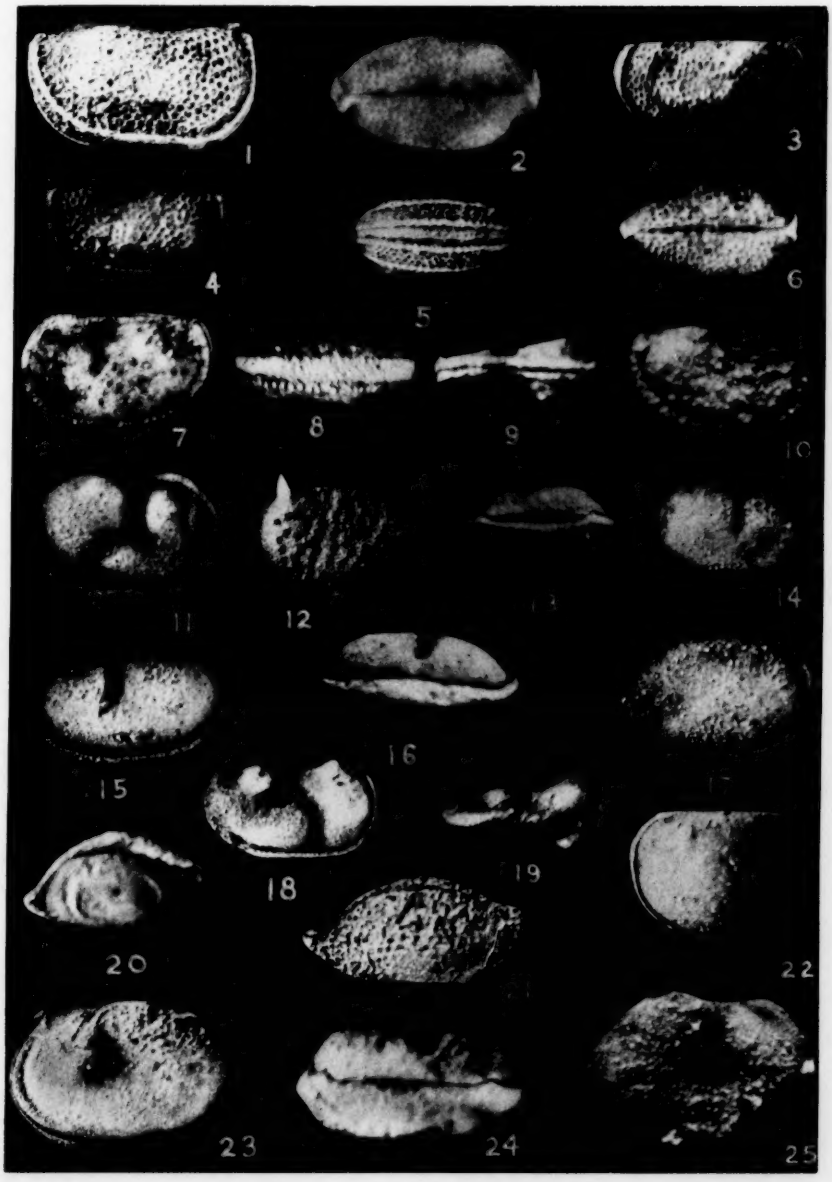
Figs. 18–19. *Perprimitia funkhouseri* Croneis and Thurman, n. sp.; fig. 18, left valve, ×45; fig. 19, dorsal view, ×45.

Fig. 20. *Bairdiolites brevirostris* Croneis and Thurman, n. sp.; right valve, ×35.

Fig. 21. *Bairdia galei* Croneis and Thurman, n. sp.; right valve, ×35.

Fig. 22. *Paraparchites kinkaidensis* Croneis and Thurman, n. sp.; left valve, ×35.

Figs. 23–25. *Carboprimitia simulans* Croneis and Thurman, n. sp.; fig. 23, left valve, ×35; fig. 24, dorsal view, ×35; fig. 25, right valve, ×35.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EXPLANATION OF PLATE VIII

(All figures are of holotypes; magnifications are approximations accurate to within 4 percent.)

Figs. 1–2. *Glyptopleura reniformis* Croneis and Thurman, n. sp.; fig. 1, left valve, ×35; fig. 2, dorsal view, ×35.

Fig. 3. *Glyptopleura adunca* Croneis and Thurman, n. sp.; right valve, ×35.

Fig. 4. *Glyptopleura compta* Croneis and Thurman, n. sp.; left valve, ×35.

Fig. 5. *Glyptopleura teretiformis* Croneis and Thurman, n. sp.; left valve, ×35.

Fig. 6. *Glyptopleura varicostata* Croneis and Thurman, n. sp.; left valve, ×35.

Fig. 7. *Glyptopleura pseudosulcata* Croneis and Thurman, n. sp.; right valve, ×40.

Fig. 8. *Glyptopleura kellettae* Croneis and Thurman, n. sp.; right valve, ×40.

Fig. 9. *Amphissites biforatus* Croneis and Thurman, n. sp.; right valve, ×50.

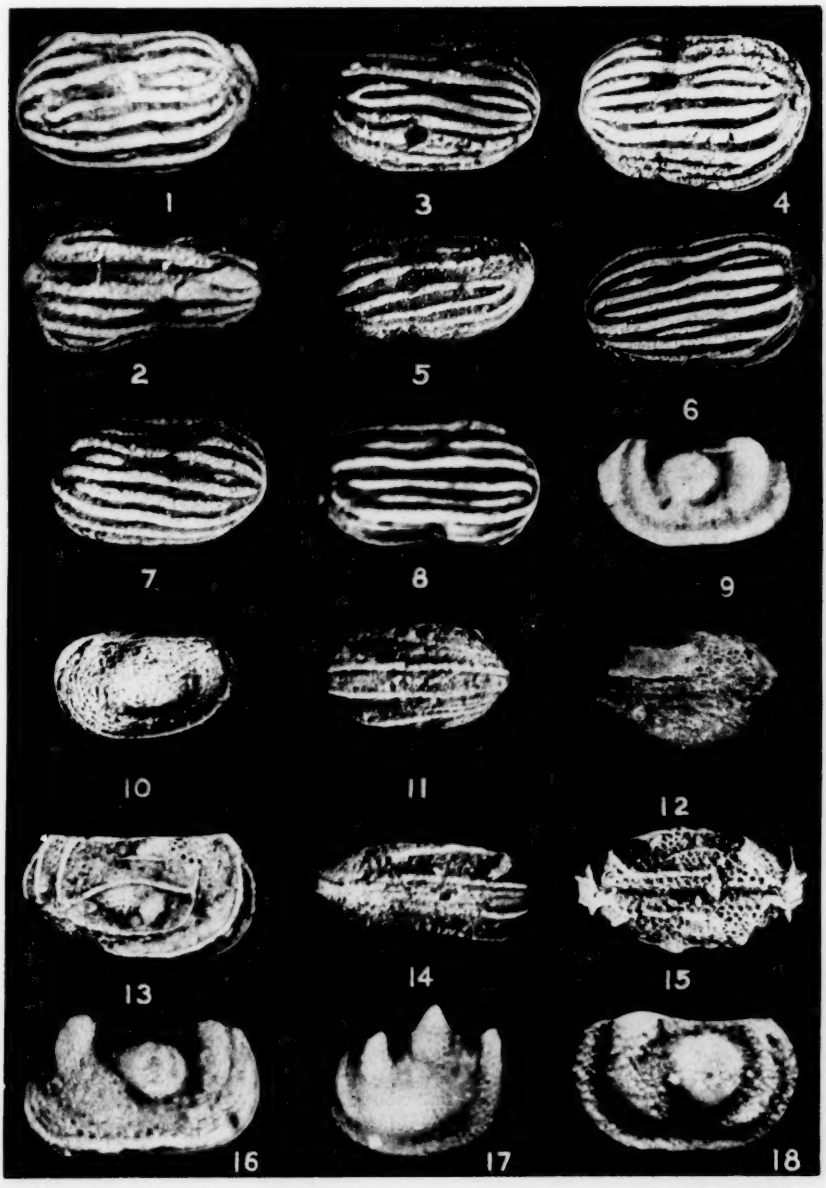
Figs. 10–12. *Amphissites bicarinatus* Croneis and Thurman, n. sp.; fig. 10, right valve, ×45; fig. 11, dorsal view, ×45; fig. 12, ventral view, ×45.

Figs. 13–15. *Amphissites insignis* Croneis and Thurman, n. sp.; fig. 13, right valve, ×35; fig. 14, ventral view, ×35; fig. 15, dorsal view, ×35.

Fig. 16. *Amphissites sublineatus* Croneis and Thurman, n. sp.; left valve, ×35.

Fig. 17. *Balantoides reticulatus* Croneis and Thurman, n. sp.; right valve, ×45.

Fig. 18. *Amphissites fossilis* Croneis and Thurman, n. sp.; left valve, ×35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NEW OSTRACODES FROM THE CLORE FORMATION[1]

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INTRODUCTION

The micropaleontologic study of the Chester (late Mississippian) samples in the collection of the Illinois Geological Survey was undertaken by the senior author a number of years ago at the suggestion of Dr. M. M. Leighton. Although this general investigation is still far from completed, recent drilling activity in the Illinois oil basin has made it imperative that at least progress reports be published on the studies of the fossil ostracodes. Particularly is this true since representatives of this group have an important utilitarian usage in the subsurface correlation of the Chester sediments commonly penetrated in the search for oil. Accordingly there are described in this paper some of the new species of ostracodes which should be encountered in well cuttings from the Clore formation.[2]

ACKNOWLEDGMENTS

The material yielding the ostracodes described in this paper was obtained from outcrops of the Clore formation in southern Illinois. Most of the collecting was done by Mr. L. E. Workman and Mr. J. E. Lamar of the Illinois Geological Survey, or by members of that organization under their direct supervision. Some of the ostracodes had also been sorted out and studied in a preliminary way by Mr. J. E. Lamar, before the samples were sent to Walker Museum. To both of these men and their staffs,

[1] Published with the permission of Dr. M. M. Leighton, Chief, Illinois Geological Survey.

[2] For a more detailed Introduction and a more complete Acknowledgment applicable to all three ostracode papers in this number of the *Journal*, see Croneis and Gale (1938).

and especially to Dr. M. M. Leighton, the chief of the Illinois Geological Survey, we are pleased to acknowledge our indebtedness. We are also under obligations to a long list of anonymous, but not forgotten, graduate students whose sample preparation and preliminary sorting of the fossils facilitated not only the micropaleontologic study of the Clore but of all the other fossiliferous Chester sediments. Finally, we are indebted to Mr. Michael S. Chappers for photographic assistance.

THE CLORE FORMATION

The Clore formation occurs near the top of the Upper Mississippian Chester series, as is shown in the accompanying table of Illinoian Chester formations.

Kinkaid limestone and shale
Degonia sandstone
CLORE limestone and shale
Palestine sandstone
Menard limestone and shale
Waltersburg sandstone
Vienna limestone and shale
Tar Springs sandstone
Glen Dean limestond and shale
Hardinsburg sandstone
Golconda limestone and shale
Cypress sandstone
Paint Creek limestone and shale
Bethel sandstone
Renault limestone and shale
Aux Vases sandstone

According to Stuart Weller (1920) the Clore is apparently conformable with the underlying Palestine and the overlying Degonia sandstone, although the actual contacts have not been seen. The type section of the formation is in Randolph County, but exposures also are found in Jackson, Johnson, Pope, and Hardin counties. Lithologically the Clore formation is extremely variable. It consists chiefly of limestone, although a considerable amount of shale is present. The limestone varies from shaly, somewhat carbonaceous members through dense, hard limestone layers to members which are partly crystalline;

in color, the limestone members vary from gray or blue-gray to nearly black. The shale beds, which locally may make up more than half of the formation, are completely argillaceous to relatively calcareous in character.

The thickness of the Clore formation probably nowhere exceeds 60 feet. The maximum thickness occurs in Randolph County, but the formation thins to the southeast and is not more than 30 to 40 feet thick in Johnson and Pope counties. In Hardin County, the thickness apparently does not exceed 30 feet.

The limestone beds of the Clore formation are fossiliferous, but the preservation of the megascopic fossils is poor so that few of the forms can be specifically identified. The preservation of the fossils in the shaly beds is considerably better. Distinctive brachiopods from the formation are *Composita subquadrata* and *Spirifer increbescens* and the most important index fossil probably is *Batostomella nitidula*, which according to Weller (1920), has not been collected from any of the other Chester formations in southern Illinois.

The Clore ostracode fauna is a relatively abundant one and sufficiently diversified to be distinguished from the faunas of any of the other Chester formations. For instance, to date there have been few definitely identical species encountered in the Golconda formation, although there is considerable general similarity between the ostracode faunas of the Clore and Golconda formations. The Clore ostracodes are naturally even more closely related to the Kinkaid forms, nevertheless not many of the species noted from the latter are conspecific with the Clore forms. The work to date on the Renault-Shetlerville fauna also confirms our belief that despite the general similarity of all Chester ostracode assemblages, the Illinioan Chester formations can be distinguished on the basis of these fossils.

Due to the fact that very little work has been done in the past on the ostracodes of the late Mississippian, not much comparison of the Clore ostracodes can be made with published faunas. Some comparisons, however, have been made with related species, mainly Mississippian or Pennsylvanian in age. With the possible exception of the Fayetteville shale (Roundy,

1926) the Amsden formation of Wyoming contains the only previously described fauna which is similar to the Clore assemblage. Morey (1935) states that Branson and Greger established, with megafossils, the age of the Amsden as late Middle Mississippian and correlated it with the Ste. Genevieve formation of the Mississippi Valley; Morey concludes that the Amsden ostracodes are probably Ste. Genevieve in age, but that no positive correlation can be made because of the lack of work on the ostracodes of the Mississippian period. The various Chester ostracode faunas are so similar to the Amsden fauna that it seems probable that the Amsden may be Chester rather than pre-Chester in age; furthermore, it is even possible that the Amsden is middle or late Chester because, superficially, its ostracodes appear more similar to those of the Clore and Kinkaid faunas than to those of the Golconda fauna, at least in so far as the latter faunas are now known. It is hoped that later work will make possible more detailed correlative comparisons.

The primary types of the new species of ostracodes described in this paper are deposited in Walker Museum, University of Chicago. Comparative material will be placed on file at the Illinois Geological Survey.

LABORATORY PROCEDURE

A synopsis of the method of preparing the samples and sorting the sediments, together with a brief statement of the photographic procedure, will be found in Croneis and Gale (1938).

SYSTEMATIC DESCRIPTIONS

Class CRUSTACEA

Superorder OSTRACODA Latreille

Family Leperditellidae U and B

Sansabella harrisi Croneis and Funkhouser, n. sp.

Plate IX, figs. 7–8

Carapace subovate in outline, medium sized; hinge-line depressed, straight or slightly convex, and provided near each

cardinal angle with a small process on right valve which fits into corresponding depression on left valve. Cardinal angles subequal, approximating 130°; posterio-ventral swing more abruptly rounded than anterio-ventral swing; venter slightly rounded. Right valve overlaps left valve along free margin; ventral overlap more conspicuous than subequal anterior and posterior overlaps. Greatest height near mid-length. Surface smooth except for minute pit posterio-dorsad of center; valves almost equally convex with greatest thickness slightly anterior of pit.

Dimensions of type specimen: length, .75 mm.; height, .45 mm.; thickness, .30 mm.

Locality C2.[3]

Holotype, Walker Museum, No. 44450.

Remarks: This specimen is oriented according to Geis' revision of the genus *Sansabella* in that the right valve is considered the larger and overlaps the left.

This species is similar to *S. reversa* Morey from the Amsden formation, but *S. harrisi* may be distinguished from the Amsden species by its more rounded posterior margin, by its greater elongation in respect to height, and by the presence of the minute pit.

Genus LAMARELLA Croneis and Funkhouser, n. gen.

Valves cytherelloid in outline, right valve overlaps left around entire margin, right valve projects upward from semi-grooved line of contact with left valve except along dorsum, dorsal outline nearly straight, surface smooth except for small pit posterio-dorsal in position.

Genotype: *Lamarella thurmani* Croneis and Funkhouser, n. sp.

Remarks: Outline somewhat similar to that of *Cavellina* in type of overlap and presence of small pit; differs from *Sulcella* in type of overlap, in nearly straight instead of arched hinge-line, and in absence of anterior ridge; differs from *Ellipsella* in type of hingement, in more pronounced overlap along free margin, and in presence of pit; differs from *Sansabella* in dorsal overlap.

[3] For details regarding localities consult the register at the end of this paper.

Lamarella thurmani Croneis and Funkhouser, n. sp.

Plate IX, figs. 11–12

Carapace subovate in outline, medium sized; hinge-line slightly convex. Anterior cardinal angle rounding into slight convexity of dorsal outline; posterior cardinal angle much more defined, approximately 120°; posterio-ventral swing more abruptly rounded than anterio-ventral swing; venter slightly rounded; anterior extremity above mid-height; posterior extremity below mid-height. Right valve overlaps left around entire margin; anterior overlap most conspicuous; ventral overlap slightly more conspicuous than subequal posterior and dorsal overlaps. In dorsal view, hinge outline of right valve possesses slight offsets near cardinal angles. Surface smooth except for minute pit slightly posterior of center; ventral border of right valve pustulate; valves almost equally convex with greatest thickness near mid-length.

Dimensions of type specimen: length, .72 mm.; height, .45 mm.; thickness, .30 mm.

Locality C1.

Holotype, Walker Museum, No. 44451.

Remarks: *Lamarella thurmani* is similar in outline to *Sansabella harrisi* from the same formation, but it may be distinguished from the latter by its dorsal overlap and by the position of its extremities, the anterior extremity lying above mid-height, the posterior extremity below mid-height.

Family Primitiidae U and B

Genus CARBOPRIMITIA Croneis and Funkhouser, n. gen.

Valves deeply sulcate, right valve overlapping left along free margin with ventral overlap especially conspicuous, free margin of right valve markedly bordered, dorsum tending to be flattened, with hinge-line marked by one or two offsets which may simulate a vague tooth and socket arrangement.

Genotype: *Carboprimitia depressa* Croneis and Funkhouser, n. sp.

Remarks: Distinguished from *Primitia* by the bordered condition of the right valve; distinguished from *Laccoprimitia* by its deep, well defined median depression or modified sulcus.

Carboprimitia depressa Croneis and Funkhouser, n. sp.

Plate IX, figs. 1–2

Carapace large, subovate in outline; hinge-line straight or only slightly convex, somewhat depressed, and showing conspicuous offsets near the cardinal angles. Anterior cardinal approximately 105°; posterior cardinal angle approximately 120°; anterio-ventral and posterio-ventral swings well rounded and subequal; venter well rounded; centro-ventral area of right valve somewhat swollen. Right valve overlaps left completely along free margin; ventral overlap most conspicuous; anterior and posterior overlaps well developed and subequal. Surface marked by deep, large, well defined sulcus slightly anterio-dorsad of center; sulcus deepened into pit-like depression at ventral extremity with slope upward to truncated dorsum. Area of dorsal truncation of right valve somewhat larger than that of left valve; slightly elevated posterior portion of right valve truncation evident above dorsal edge of left valve in lateral view; right valve widely rimmed along free margin; left valve conspicuously flattened at anterior margin, somewhat less flattened at posterior margin. In dorsal view, surface slope broken into two parts by sulcus; posterior swelling considerably larger and somewhat thicker than anterior swelling; in posterior view, ventral area of each valve falls abruptly from convex surface to free margin. Central part of right valve conspicuously flattened. Greatest height near mid-length; greatest thickness closer to posterior than to mid-length. Surface smooth.

Dimensions of type specimen: length, 1.05 mm.; height, .69 mm.; thickness, .45 mm.

Locality C2.

Holotype, Walker Museum, No. 44452.

Remarks: The central flattening of the right valve mentioned above is not due to crushing since it is present in all of a considerable number of specimens.

C. depressa is similar to *C. rotunda* and *C. rotunda* var. *depressa* from the same formation, but it differs from them in its swollen centro-ventral area of the right valve, its considerably larger sulcus, its posterior swelling on the right valve extending markedly above the hinge-line, and its central flattening on the right valve.

Carboprimitia rotunda Croneis and Funkhouser, n. sp.

Plate IX, figs. 3–4

Carapace large, subovate in outline; hinge-line straight or slightly convex, somewhat depressed, and faintly offset near cardinal angles. Cardinal angles rounded and similar in outline to anterio-ventral and posterio-ventral swings; venter rounded. Right valve overlaps the left completely along free margin; overlap especially conspicuous on venter; anterior and posterior overlaps well developed and subequal. Surface marked by deep, well defined sulcus near mid-length; sulcus deepened into pit-like depression at ventral extremity with slope upward to truncated dorsum. Area of dorsal truncation of right valve nearly equal that of left; right valve widely rimmed along free margin; left valve conspicuously flattened along anterior margin, slightly flattened along posterior margin. In ventral view, carapace symmetrical with rim on right valve central and remainder of right valve nearly equal to and having the same, even convexity as left valve; in dorsal view, surface slope broken into two parts by sulcus, posterior swelling only slightly the larger and more elevated; surface slopes to anterior and posterior margins subequal; in posterior view, ventral area of each valve falls abruptly from gently convex surface to free margin. Greatest height near mid-length. Surface smooth.

Dimensions of type specimen: length, 1.0 mm.; height, .63 mm.; thickness, .42 mm.

Locality C1.

Holotype, Walker Museum, No. 44453.

Remarks: For differences between this species and *C. rotunda*

var. *tumida*, see remarks under same; for differences between this species and *C. depressa*, see remarks under same.

Carboprimitia rotunda var. *tumida*
Croneis and Funkhouser, n. var.

Plate IX, figs. 5–6

Carapace large, subovate in outline; hinge-line straight or slightly convex, somewhat depressed, and showing conspicuous offsets near cardinal angles. Cardinal angles rounded and similar in outline to anterio-ventral and posterio-ventral swings; venter rounded. Right valve overlaps the left completely along free margin; overlap especially conspicuous on venter, slightly less so along anterior, and weak along posterior. Surface marked by deep, well defined sulcus anterio-dorsad of center; sulcus deepened into pit-like depression at ventral extremity with slope upward to truncated dorsum. Area of dorsal truncation of right valve nearly equal that of left valve; right valve widely rimmed along free margin; left valve conspicuously flattened along anterior margin, no flattening along posterior margin. In dorsal view, surface slope broken into two parts by sulcus; posterior swelling markedly larger and somewhat thicker than anterior swelling; surface slope to posterior margin much more abrupt than surface slope to anterior margin; in posterior view, ventral area of each valve falls abruptly from convex surface to free margin. Greatest thickness closer to posterior than to mid-length; greatest height near mid-length. Surface smooth.

Dimensions of type specimen: length, 1.0 mm.; height, .66 mm.; thickness, .50 mm.

Locality C1.

Holotype, Walker Museum, No. 44454.

Remarks: *C. rotunda* var. *tumida* is very similar in lateral view to *C. rotunda* from the same formation; however, the variety may be distinguished from *C. rotunda* by its less developed posterior overlap, by its somewhat more conspicuously offset hinge-line, and, most important, by the abrupt slope of its comparatively large posterior swelling to the posterior margin.

It is possible, if not probable, that the variety is merely the female form of the species.

Family Primitiopsidae Swartz

Genus PRIMITIOPSIS Jones

Primitiopsis ? striatus Croneis and Funkhouser, n. sp.

Plate X, fig. 13

Carapace small and elongate, subrectangular to subovate in outline; hinge-line nearly straight. Posterior cardinal angle approximately 100°; anterior cardinal angle approximately 160°; anterior end nearly uniformly rounded; posterior end more broadly rounded; posterio-ventral swing slightly angular; anterio-ventral swing well rounded; venter nearly straight and paralleling hinge-line. Brood pouch (?) at posterior set off from rest of carapace by a regular, abrupt, downward shell slope paralleling the posterior margin; greatest thickness of valve slightly to anterior of line of brood pouch demarcation. Minute sulcus or modified pit lies dorsad and slightly to anterior of center. Surface marked by number of fine, sublongitudinal striae; in central part of valve, the striae roughly parallel the hinge-line; slightly to anterior of brood pouch the striae curve in varying degree and cross each other to form a highly complex area of surface marking; striae somewhat concentrically arranged anteriorly; brood pouch (?) comparatively smooth.

Dimensions of type specimen: length, .48 mm.; height, .27 mm.; thickness (one valve), .10 mm.

Locality C2.

Holotype, Walker Museum, No. 44455.

Remarks: This species has been doubtfully referred to the genus *Primitiopsis* because the surface is striate rather than reticulate. It may well represent a new genus.

The new species is based on a single well preserved right valve; no evidence of overlap is present nor is there any dentition developed. The interior of the thin shelled valve is full of matrix so it is not known if the brood pouch (?) is separated from the rest of the carapace.

Family Hollinidae Swartz

Genus HOLLINELLA Coryell

Hollinella sp.

Plate IX, fig. 15

Carapace large with portion of anterior missing; hinge-line straight. Posterior cardinal angle approximately 100°; posterio-ventral swing well rounded. Free margin of valve bordered by a wide frill which rapidly increases in size from posterior cardinal angle to mid-height, remaining approximately same size to broken portion. Surface marked by two nodes separated by a depression; posterior node much the smaller and slightly elongate vertically. Surface, except frill, finely and regularly reticulate.

Dimensions of specimen: length (broken), .90 mm.; height, .75 mm.

Locality C1.

Specimen, Walker Museum, No. 44456.

Remarks: There are several fragments of this species in the Clore collection but a complete specific description is at present impossible since all specimens lack an anterior end.

This species is similar to *H. typica* Morey of the Amsden formation, but differs from the latter in the greater distance from the posterior frill to the posterior node, and in the finely reticulate surface. Other differences will no doubt be evident on the discovery of better specimens from the Clore formation.

Family Kloedenellidae U and B

Genus NEOKLOEDENELLA Croneis and Funkhouser, n. gen.

Valves subequal with little or no overlap, surface marked by slight anterio-dorsal depression, hinge-line slightly depressed, right valve with small process near the anterior cardinal angle fitting into corresponding depression on left valve; process may be poorly developed.

Genotype: *Neokloedenella prima* Croneis and Funkhouser, n. sp.

Remarks: Similar to *Eukloedenella* in outline but with reverse orientation. Distinguished from *Eukloedenella* by lack of overlap

and pit, and by process near the anterior rather than the posterior cardinal angle.

Neokloedenella prima Croneis and Funkhouser, n. sp.

Plate X, figs. 8–10

Carapace inflated, subrectangular to subovate in outline, large; length slightly less than twice height; hinge-line straight or slightly convex, inconspicuously depressed; right valve having a small process fitting into a corresponding depression on left valve near anterior cardinal angle. Posterior cardinal angle approximately 100°; anterior cardinal angle approximately 150°; anterio-ventral and posterio-ventral swings well rounded and nearly equal; venter slightly concave. Right and left valves subequal with no overlap; valves sharply separated by slightly rolled free margins. In ventral view, posterior well rounded with very gentle slope to less rounded anterior; greatest thickness midway between middle of carapace and posterior. Surface smooth except for broad, inconspicuous depression anterio-dorsad of center.

Dimensions of type specimen: length, .90 mm.; height, .48 mm.; thickness, .45 mm.

Locality C2.

Holotype, Walker Museum, No. 44457.

Remarks: If the orientation of *Neokloedenella prima* were reversed, it would be almost identical in outline with *Eukloedenella umbilicata* Ulrich and Bassler from the McKenzie (Silurian) formation. *N. prima* may be distinguished from the much older species by its lack of overlap, by its lack of a pit, by its anterio-dorsal depression, and by its area of greatest thickness being posterior.

Genus JONESINA U and B

Jonesina insculpta Croneis and Funkhouser, n. sp.

Plate X, figs. 21–22

Carapace subovate in outline, medium sized; hinge-line slightly convex, offset near cardinal angles, and conspicuously

depressed. Rolled edge of left valve markedly overlaps right valve along free margin from angle to angle; overlap strongest on venter. Cardinal angles obtuse and nearly equal, anterio-ventral swing less rounded than posterio-ventral swing; venter slightly rounded. Surface marked by a deep, well defined sulcus which is posterior of mid-length; a poorly defined node lies on each side of sulcus; in lateral view, posterior node is better defined and extends slightly farther ventrad than the more rounded anterior node; in dorsal view, anterior node slightly the more pronounced; nodes joined by a slightly undulant loop which roughly parallels the ventral edge of valve; loop merges into posterio-central portion of posterior node and forms ventral edge of anterior node. Posterior and ventral borders of right valve abruptly elevated above free edge; gentle slope from anterior edge to anterior node. Greatest thickness through anterior nodes; greatest height near mid-length.

Dimensions of type specimen: length, .84 mm.; height, .50 mm.; thickness, .30 mm.

Locality C2.

Holotype, Walker Museum, No. 44458.

Remarks: This species is very similar to *J. bolliaformis* (Ulrich and Bassler) from the Cottonwood formation, but the new species may be distinguished from the latter by its much more conspicuous overlap, especially on the anterior and posterior ends, and by its considerably larger nodes.

Jonesina spinosa Croneis and Funkhouser, n. sp.

Plate X, fig. 14

Carapace subovate in outline, medium sized; hinge-line straight or nearly so. Posterior cardinal angle approximately 130°; anterior cardinal angle approximately 150°; anterio-ventral swing more gently rounded than posterio-ventral swing; venter slightly rounded. Surface marked by well defined sulcus slightly posterior to mid-length; sulcus narrowed at its mid-length, flaring slightly at its ventral extremity, broadly flared near dorsum; posterior edge of sulcus formed by small, indistinct,

circular node; anterior edge of sulcus formed by small node bearing near the cardinal angle a thick, blunt, anteriorly-pointed spine which extends slightly above hinge-line in lateral view; ventrad of sulcus, valve is slightly more swollen than at lobes. Greatest height closer to posterior than to mid-length. In ventral view, surface almost uniformally convex; greatest thickness somewhat posterior and ventrad of center.

Dimensions of type specimen: length, .60 mm.; height, .35 mm.; thickness (one valve), .15 mm.

Locality C2.

Holotype, Walker Museum, No. 44459.

Remarks: This species is similar to *J. persulcata* from the Golconda formation, but *J. spinosa* may be distinguished from the latter by its blunt spine, the ventral flaring of its sulcus, and its more rounded anterior cardinal angle.

Genus DELOIA Croneis and Thurman

Deloia sulcata Croneis and Funkhouser, n. sp.

Plate IX, fig. 18

Carapace subrectangular to subovate in outline, medium sized; hinge-line straight or nearly so. Posterior cardinal angle approximately 100°; anterior cardinal angle approximately 135°; posterio-ventral swing less abruptly rounded than anterio-ventral swing; venter slightly rounded. Free margin of valve bordered by a conspicuous, flat rim, slightly tuberculate at outer edge. Surface marked by narrow, well defined sulcus slightly anterior of mid-length; sides and base of sulcus form a narrow, vertically elongate "U" which expands broadly near dorsum; an inconspicuous ridge with origin near anterior cardinal angle drops vertically to below mid-height, curving to posterior with anterio-ventral swing, and joining marginal rim at mid-venter. Greatest height at mid-length. Valve considerably swollen in posterio-dorsal region with abrupt and subequal slopes to posterior rim and to sulcus, less abrupt slope to venter; anterio-ventral portion of valve slightly swollen.

Dimensions of type specimen: length, .80 mm.; height, .48 mm.; thickness (one valve), .18 mm.

Locality C1.

Holotype, Walker Museum, No. 44460.

Remarks: The inconspicuous anterior ridge mentioned above is not shown in the photograph; nevertheless, it can be seen with strong cross-lighting.

This species is similar to *D. serrata* from the Kinkaid formation, but *D. sulcata* may be distinguished from the latter by its longer and more narrow sulcus, and by its more abruptly rounded posterio-ventral swing.

Family Kirkbyidae U and B

Genus KIRKBYA Jones

Kirkbya aequalis Croneis and Funkhouser, n. sp.

Plate X, figs. 17–19

Carapace inflated, subsemicircular to subrectangular in outline, medium sized; hinge-line depressed, straight or nearly so. Cardinal angles nearly equal, approximating 90°; posterio-ventral and anterio-ventral swings well rounded and subequal; mid-venter only slightly convex. Free margin bordered by narrow marginal and submarginal flanges; marginal flange only slightly evident in lateral view; flanges more widely separated on venter than on extremities, where they tend to converge. A swelling with greatest elevation in anterio-dorsal region slopes abruptly to anterior submarginal flange, less abruptly ventrad and dorsad, and gently to posterior. Greatest height near mid-length. A well defined, oval pit whose long dimension parallels the hinge-line lies considerably ventrad of center. Surface, and area between inner and outer flanges, finely and regularly reticulate; valve border between marginal flanges non-reticulate.

Dimensions of type specimen: length, .60 mm.; height, .30 mm.; thickness, .30 mm.

Locality C1.

Holotype, Walker Museum, No. 44461.

Remarks: This species is somewhat similar to *K. turrita* from the Golconda formation, but *K. aequalis* may be distinguished from the latter by its more symmetrical outline, by its lack of a

definite ridge, and by the presence of a well defined, oval pit somewhat ventrad of center.

Kirkbya marginata Croneis and Funkhouser, n. sp.

Plate X, fig. 20

Carapace large, subrectangular in outline; hinge-line straight or slightly convex. Cardinal angles slightly more than 90° and subequal; posterior and anterior ends nearly straight from cardinal angles to slightly below mid-height; anterio-ventral and posterio-ventral swings well rounded and nearly equal; venter straight or slightly convex. Free margin bordered by marginal and submarginal flanges, both visible in lateral view; flanges widely separated on venter, converging toward cardinal angles. A swelling with greatest elevation mid-anterior slopes abruptly to anterior submarginal flange, slightly less abruptly toward venter and dorsum, gently to posterior. Pit not evident. Surface coarsely and regularly reticulate except for essentially smooth area between marginal flanges.

Dimensions of type specimen: length, .90 mm.; height, .40 mm.; thickness, .30 mm.

Locality C3.

Holotype, Walker Museum, No. 44462.

Remarks: Specimen slightly damaged, but not enough to obliterate major features. This species is somewhat similar to *K. regularis* from the Golconda formation, but *K. marginata* may be distinguished from the latter by its two flanges evident in lateral view, and by its more coarsely reticulate surface.

Genus AMPHISSITES Girty

Amphissites rothi Croneis and Funkhouser, n. sp.

Plate X, fig. 15

Carapace subrectangular to subovate in outline, medium sized; hinge-line depressed, straight or slightly concave. Anterior cardinal angle slightly more rounded than posterior cardinal angle; posterio-ventral and anterio-ventral swings well rounded and subequal; ventral margin nearly straight. In lateral view, free

margin bordered by slightly elevated ridge; in ventral view, free margin bordered by narrow flange which is separated from flange on opposite valve by conspicuous smooth area extending from angle to angle; flanges nearly equidistant from each other except for slight widening near center of venter; slope from marginal ridge to marginal flange nearly vertical so that marginal flanges are not evident in lateral view. Surface marked by three prominent nodes; anterio-dorsal node, largest and broadest of the three, slopes abruptly dorsally and anteriorly, less abruptly to posterior, and gently toward the venter; ventral extension of anterio-dorsal node parallels the anterio-ventral swing until it merges with the general surface near the pit; median node posterio-dorsad of center, nearly circular in outline, and steeply rounded on all sides; posterio-dorsal node, smaller than the other two, sloping steeply dorsally and posteriorly, slightly less abruptly to the anterior, tapering gently toward the venter and merging with the general surface at about mid-height of median node; posterio-dorsal and anterio-dorsal nodes extend slightly above hinge-line in lateral view. In dorsal view, median node considerably more elevated than anterio-dorsal node; posterio-dorsal node only slightly elevated. A large, oval pit, whose long dimension is posterio-ventral to anterio-dorsal in position, lies at the anterio-ventral base of median node. Surface finely and regularly reticulate.

Dimensions of type specimen: length, .66 mm.; height, .40 mm.; thickness (one valve), .20 mm.

Locality C3.

Holotype, Walker Museum, No. 44463.

Remarks: This common Clore species is similar to *A. trilobus* from the Golconda formation and to *A. sublineatus* from the Kinkaid formation. *A. rothi* may be distinguished from *A. trilobus* by its larger anterio-dorsal node, its less sharply delineated posterio-dorsal node, its slightly more circular median node, the presence of a large, well defined pit, and by the circular rather than linear reticulations. *A. rothi* may be distinguished from *A. sublineatus* by its less flared and less sharply delineated anterio-dorsal node, and by its circular rather than linear reticulations.

This form is similar to the often cited *A. tricollina* (Jones and Kirkby) from the "Chester" formation. It differs from the latter, however, in that the nodes are longer and broader, the median node is more posterior in position, the marginal ridge is more elevated, and the anterior and posterior outlines are more rounded.

A. rothi varies in length from .50 to .90 mm., but the characteristics remain essentially the same throughout its entire range in size.

Genus BALANTOIDES Morey

Balantoides moreyi Croneis and Funkhouser, n. sp.

Plate X, fig. 16

Carapace small, subrectangular in outline; hinge-line straight or nearly so. Anterior cardinal angle slightly more than 90°; posterior cardinal angle approximately 110°; posterior end rounded; anterior end nearly straight; posterio-ventral swing rounded into venter; anterio-ventral swing rounded and joining venter with slight break in curvature; venter well rounded. Surface marked by three prominent, flat-lying, spine-like nodes and a minor node; most prominent node lies near mid-length, originating near mid-height and extending considerably above hinge-line; anterior node originating at anterio-ventral swing, longer but less pronounced than central node, extending somewhat above hinge-line at anterior cardinal angle, and set off from rest of valve by fairly conspicuous depression extending from venter to dorsum; major posterior node originating near mid-height and extending very slightly above hinge-line, considerably smaller than the other two major nodes; minor node located at posterior near mid-height. Free margin of valve slopes abruptly upward into only slightly rounded central portion. Greatest thickness slightly dorsad and posterior of center; greatest height, disregarding nodes, considerably posterior of mid-length. In dorsal view, surface has marked tri-lobed outline. Surface finely reticulate. Overlap undetermined.

Dimensions of type specimen: length, .55 mm.; height, .35 mm.; thickness (one valve), .12 mm.

Locality C2.

Holotype, Walker Museum, No. 44464.

Remarks: This species is similar to *B. quadrilobatus* Morey from the Amsden formation, but the new species may be distinguished from the latter by its spine-like terminations of the nodes and by its lack of a sulcus splitting the posterior node.

A similar or conspecific form occurs in the Kinkaid formation.

Family Glyptopleuridae Girty

Genus GLYPTOPLERA Girty

Glyptopleura alata Croneis and Funkhouser, n. sp.

Plate X, fig. 3

Carapace large, subquadrate to subovate in outline; hinge-line straight. Anterior cardinal angle approximately 125°; posterior cardinal angle approximately 140°; posterio-ventral swing more abruptly rounded than anterio-ventral swing. Surface marked by a series of prominent ridges which more nearly parallel each other than the hinge-line; ridges have a slight upward slope from anterior to posterior. The dorsal and ventral ribs form a broad "U" with its base anterior. First rib ventrad of dorsal arm of broad "U" joins the "U" at a point near the center of anterior; first rib dorsad of ventral arm joins the broad "U" at the anterio-ventral swing; these two ribs, which are longer and stronger than the enclosing ones, thus form a less broad "U" whose base is a part of base of broad "U". Implanted within the less broad "U" are three more ribs; the two ventrad of the three ribs form a very narrow "U" whose base lies slightly to posterior of base of the combined "U's". A minor rib lies near mid-length between the ventral arms of the two larger "U's". Dorsal arm of very narrow "U" and both arms of intermediate "U" terminate somewhat closer to the posterior edge than do the other ribs. Dorsal of three implanted ribs is separated into two parts by a prominent, nearly circular pit which lies in a position somewhat anterio-dorsad of center. Dorsal arm of broadest "U" is also broken directly above pit. Greatest height near posterior; greatest thickness in posterior third of valve.

Dimensions of type specimen; length, 1.0 mm.; height, .65 mm.; thickness (one valve), .30 mm.

Locality C1.

Holotype, Walker Museum, No. 44465.

Remarks: All species of *Glyptopleura* described in this paper are oriented in accordance with Geis' interpretation, that is, with region of greatest thickness posterior in position.

This species may be distinguished from *G. alternata*, *G. similis*, and *G. symmetrica* of the same formation by the joining of its two ventrad of the three implanted ribs to form a very narrow "U".

G. alata may be distinguished from *G. similis* and *G. symmetrica* by its minor rib between the two dorsal arms of the two large "U's".

For further comparisons see remarks under *G. symmetrica*.

Glyptopleura alternata Croneis and Funkhouser, n. sp.

Plate X, fig. 7

Carapace large, subrectangular to subovate in outline; hinge-line straight or nearly so. Cardinal angles blunted; posterior angle slightly more than 90°; anterior angle approximately 130°; posterio-ventral swing more gently rounded than anterio-ventral swing; posterior outline nearly straight; anterior outline broadly rounded; venter slightly rounded. Surface marked by series of ridges which are alternately weak and strong. Weak, interrupted dorsal rib and strong ventral rib form a broad "U" with base anterior; first rib ventrad of dorsal rib and first strong rib dorsad of ventral rib form a less broad "U" which shares part of base of broad "U"; a minor rib lies near center between ventral arms of the two "U's". Implanted within the less broad "U" are three ribs; central rib longest and strongest, dorsal rib limited to anterio-dorsal position, ventral rib not as strong as ribs ventrad and dorsad of it; implanted ribs do not join anteriorly. Strong ribs terminate at nearly equal distances from posterior edge. A circular pit lies somewhat dorsad of mid-height and ventrad

of dorsal arm of less broad "U". Greatest thickness in posterior third; greatest height near mid-length.

Dimensions of type specimen: length, .90 mm.; height, .60 mm.; thickness, .40 mm.

Locality C1.

Holotype, Walker Museum, No. 44466.

Remarks: This species may be distinguished from similar species in the formation by its alternate weak and strong ribs, by its possession of only two "U's", and by the greatly reduced size of the third rib from dorsum.

This species is similar to *G. decacostata* from the Golconda formation in that it also possesses alternate weak and strong ribs, but *G. alternata* may be distinguished from the latter by its nearly equal anterior and posterior ends, and by the extension of its ribs almost to the posterior edge.

This species may be distinguished from *G. reniformis*, *G. varicostata*, and *G. pseudosulcata* of the Kinkaid formation by its alternate weak and strong ribs.

Glyptopleura complexa Croneis and Funkhouser, n. sp.

Plate X, fig. 2

Carapace subovate in outline, medium sized; hinge-line straight or nearly so. Anterior cardinal angle approximately 140°; posterior cardinal angle approximately 110°; anterior end more rounded than posterior; anterio-ventral swing more abruptly rounded than posterio-ventral swing; venter only slightly convex. Free margin of valve slightly flanged. Surface marked by wide, convoluting ridges, the strongest of which are united at both ends of valve near mid-height; ridges have slight upward slope from anterior to posterior. Central ridge, originating near or a little above middle of posterior, is broken just anterior of mid-length, slopes to anterior where an abrupt downward swing, followed immediately by a complete turn upward results in a pick-like outline; the central ridge is markedly expanded toward the posterior; the upper-most part of the pick-like anterior con-

tinuation of the central ridge swings backward, first with a broad, sigmoidal curve, then in a reasonably straight but undulant line toward the posterior cardinal angle, where it turns downward and swings completely around the point of origin of the central ridge and slopes with slight undulation to anterio-ventral swing, where the ridge again abruptly swings around backward and continues along venter; ridge along venter with several extensions to ventral margin and fingering out in posterio-ventral area; in the anterio-dorsal area, a ridge branching from the posteriorly-turned ridge roughly parallels the anterio-dorsal swing, pinching out somewhat posterior of mid-length; the latter ridge has a regularly jagged dorsal border and an undulating ventral edge. A nearly circular pit, slightly anterio-ventral in position, lies above the broken portion of central ridge. Greatest height near mid-length; greatest thickness in posterior third of valve.

Dimensions of type specimen: length, .70 mm.; height, .40 mm.; thickness (one valve), .20 mm.

Locality C3.

Holotype, Walker Museum, No. 44467.

Remarks: This species is similar to an as yet undescribed form from the Renault-Shetlerville formation.

G. complexa is somewhat similar to *G. karli* Geis from the Salem formation, but it may be distinguished from the latter by its more undulant ribs, the posterior swelling of its central rib, the anterior continuation of its central rib, and the presence of only one ventral rib.

Glyptopleura similis Croneis and Funkhouser, n. sp.

Plate X, fig. 4

Carapace large, subovate to subquadrate in outline; hinge-line slightly convex. Anterior cardinal angle approximately 150°; posterior cardinal angle approximately 110°; anterio-ventral and posterio-ventral swings well rounded and subequal; venter slightly convex. Surface marked by a series of prominent ridges that more nearly parallel each other than the hinge-line; ridges have a slight upward slope from anterior to posterior. Dorsal

and ventral ribs form a broad "U" with its base anterior. First rib ventrad of dorsal arm of broad "U" joins the "U" at a point near center of posterior; first rib dorsad of ventral arm of broad "U" joins the "U" at the anterio-ventral swing; these two ribs, which are longer and stronger than the enclosing ribs, thus form a less broad "U" whose base is a part of base of broader "U". Implanted within the less broad "U" are three more ribs; the ventrad of these three terminates anteriorly before joining the "U"; the two dorsad of the three ribs form a very narrow "U" whose base lies slightly to posterior of base of the combined "U's". Ventral arm of very narrow "U" and both arms of intermediate "U" terminate somewhat closer to posterior edge than do the other four ribs. Dorsal arm of very narrow "U" is separated into two parts by a prominent, nearly circular pit which lies in a position somewhat dorsad and anterior of center. Dorsal arm of broadest "U" is also broken directly above the pit. Greatest height closer to posterior than to mid-length; greatest thickness in posterior third.

Dimensions of type specimen: length, 1.05 mm.; height, .57 mm.; thickness (one valve), .30 mm.

Locality C1.

Holotype, Walker Museum, No. 44468.

Remarks: *G. similis* may be distinguished from similar species in the formation by the joining of the two dorsad of the three implanted ribs to form a very narrow "U".

G. similis may be distinguished from *G. adunca* of the Kinkaid formation by its less undulant ribs, by its posterior joining only of the dorsad and central of the three implanted ribs, and by the absence of the minor rib between the ventral arms of the two broad "U's".

For further comparisons see remarks under *G. symmetrica.*

Glyptopleura symmetrica Croneis and Funkhouser, n. sp.

Plate X, fig. 1

Carapace large, subquadrate to subovate in outline; hingeline straight or nearly so. Cardinal angles subequal, approxi-

mating 135°; posterio-ventral swing more gently rounded than anterio-ventral swing; venter slightly convex. Surface marked by series of ridges that more nearly parallel each other than the hinge-line; ridges have slight upward slope from anterior to posterior. Dorsal and ventral ribs form a broad "U" with base anterior. First rib ventrad of dorsal rib joins broad "U" slightly below mid-height; first rib dorsad of ventral rib joins broad "U" at center of anterio-ventral swing; these two ribs thus form a less broad "U" which shares a portion of base of broad "U". Implanted within the less broad "U" are three more ribs; the dorsad and ventrad of the three ribs form a narrow "U" whose base lies slightly posterior to combined base of the other two "U's"; the central rib joins the markedly thinner base of the narrow "U" at the anterior. Posterior ends of ribs tend to converge. Dorsal arm of narrow "U" broken near mid-length by pit. Greatest height near mid-length; greatest thickness in posterior third.

Dimensions of type specimen: length, 1.0 mm.; height, .65 mm.; thickness (one valve), .24 mm.

Locality C4.

Holotype, Walker Museum, No. 44469.

Remarks: *G. symmetrica* is similar to *G. similis*, *G. alata*, and *G. alternata* from the same formation, but the differences are regularly found; for the present, therefore, these four similar forms are regarded as separate entities and not as different molts or varieties of a single species.

G. symmetrica may be distinguished from the three other species by its anterior fusion of the three ribs implanted in the intermediate "U", by its proportionately wider ribs and narrower separating grooves, and by the marked convergence of all the ribs at the posterior.

G. symmetrica, *G. alata*, and *G. similis* of the Clore formation constitute a group of species which may be distinguished from *G. varicostata*, *G. reniformis*, and *G. pseudosulcata*, a similar group found in the Kinkaid formation, by the anterior joining of two or all three of the implanted ribs in the former group.

G. symmetrica may be distinguished from *G. compta* of the

Kinkaid formation by its anterior fusion of all three of the implanted ribs, by its lack of posterior joining of the dorsad and middle implanted ribs, and by the anterio-ventral rather than mid-height location of the base of the "U's".

Glyptopleura varians Croneis and Funkhouser, n. sp.

Plate X, figs. 5–6

Carapace subquadrate to subovate in outline, medium sized; hinge-line straight or nearly so. Anterior cardinal angle slightly more than 90°; posterior cardinal angle approximately 135°; anterior end only slightly convex; posterio-ventral swing extending to mid-height of posterior and less abruptly rounded than anterio-ventral swing; venter slightly rounded. Surface marked by a prominent "U" with base anterior in position and somewhat ventrad of mid-height; ribs more nearly parallel each other than the hinge-line. A rib which is implanted in the "U" is considerably shorter than the enclosing ribs; ventral rib about half the length of ventral arm of "U"; anterio-dorsal rib small and inconspicuous. In dorsal view, right and left valves show considerable difference near posterior; right valve slopes abruptly inward before left valve does; posterior extremity thinnest portion of carapace because of inward slope of valves before reaching posterior. A prominent, nearly circular pit lies between the implanted rib and the dorsal arm of "U" in a position somewhat dorsad of center. Greatest thickness considerably posterior of mid-length; greatest height near mid-length.

Dimensions of type specimen: length, .60 mm.; height, .35 mm.; thickness, .20 mm.

Locality C1.

Holotype, Walker Museum, No. 44470.

Remarks: This species undoubtedly belongs to the *G. parvacostata-G. intermedia* line and resembles the latter rather closely. It may however be distinguished from the latter Golconda species by the presence of only one rib implanted in the "U", and by its less ovate outline. *G. parvacostata* Geis from the Salem formation does not have a rib implanted in the "U".

The base of the "U" mentioned above is broken in the specimen pictured, but the "U" is complete in several specimens which are otherwise too damaged to use.

Family Bairdiidae Lienenklaus

Genus BAIRDIOLITES Croneis and Gale

Bairdiolites elongatus Croneis and Funkhouser, n. sp.

Plate IX, figs. 16–17

Carapace elongately subhexagonal in outline, medium sized; length two and a half times height. Left valve overlaps right except possibly near center of dorsum; overlap thin; anterio-dorsal overlap slightly more conspicuous than regular ventral overlap; posterio-dorsal overlap inconspicuous. Dorsal outline angular; center of dorsum nearly straight and sloping slightly to posterior; posterio-dorsal outline slightly concave; anterio-dorsal outline slightly convex; anterio-ventral outline much more abruptly rounded than posterio-ventral outline; mid-portion of ventral outline nearly straight and essentially parallel to center of dorsum. Posterior extremity acuminate and projecting at slightly below mid-height of carapace; anterior extremity angular and somewhat above mid-height. Greatest thickness near mid-length. Surface marked by two fairly conspicuous, crescentic ridges whose convex outlines are directed toward the shell extremities; one ridge posterio-central, the other anterio-central in position. In dorsal view, surface between ridges gently convex with slightly greater and subequal slopes from ridges to extremities. Surface within ridges slightly more roughened than surface outside ridges.

Dimensions of type specimen: length, .75 mm.; height, .30 mm.; thickness, .25 mm.

Locality C1.

Holotype, Walker Museum, No. 44471.

Remarks: The type specimen may be slightly damaged in the centro-dorsal area so it is possible that the overlap is complete instead of as stated above. This species is easily distinguished from other *Bairdiolites* by its much greater length in respect to its height.

Bairdiolites ovatus Croneis and Funkhouser, n. sp.

Plate IX, figs. 13–14

Carapace subovate in outline, medium sized; length one and a half times height. Left valve overlaps right around entire margin; overlap thin, slightly more pronounced on dorsum than on venter. Dorsal outline of left valve well rounded except for flattening near posterior angle; dorsal outline of right valve well rounded except for slight angulation in posterio-dorsal swing; mid-portion of ventral outline straight or nearly so; anterio-ventral outline much more abruptly rounded than posterio-ventral outline. Posterior extremity bluntly acuminate and considerably below mid-height; anterior extremity almost uniformly rounded and nearly at mid-height. Surface marked by two thin, crescentic ridges, one ridge anterio-central, the other posterio-central in position; ridges tend to make a rough circle not closed on ventral or dorsal edges. In dorsal view, central area gently convex with slope from posterior ridge to margin slightly more abrupt than slope from anterior ridge to margin. Greatest height near mid-length; greatest thickness near mid-length. Surface inside and outside ridges essentially smooth.

Dimensions of type specimen: length, .70 mm.; height, .45 mm.; thickness, .30 mm.

Location C1.

Holotype, Walker Museum, No. 44472.

Remarks: This species is similar to *B. platypleurus* from the Golconda formation, but *B. ovatus* may be distinguished by its more ovate outline, by its ridges tending to form a rough circle, and by its essentially smooth rather than pustulose area between the ridges.

Genus BYTHOCYPRIS Brady

Bythocypris clorensis Croneis and Funkhouser, n. sp.

Plate X, figs. 11–12

Carapace small, subovate in outline. Left valve overlaps right around entire margin; ventral and posterior overlaps subequal and somewhat stronger than dorsal and anterior overlaps; overlap

weakest near middle of dorsum. Dorsal outline broadly convex with slight central angulation; posterior and anterior outlines almost equally rounded with extremities at about mid-height; ventral outline straight or very slightly concave. Greatest height at mid-length; vertical line at mid-length would divide carapace into two nearly equal portions. In dorsal view, surface broadly and evenly convex with greatest thickness central or slightly posterior of center. Surface smooth.

Dimensions of type specimen: length, .50 mm.; height, .33 mm.; thickness, .20 mm.

Locality C2.

Holotype, Walker Museum, No. 44473.

Remarks: This species may be distinguished from *B. amsdenensis* Morey from the Amsden formation by its more equal anterior and posterior outlines and by its complete overlap; nevertheless, the Amsden species is a closely related form.

Family Cytherellidae Sars

Genus CAVELLINA Coryell

Cavellina ovalis Croneis and Funkhouser, n. sp.

Plate IX, figs. 9–10

Carapace large, subovate in outline; right valve flanged to receive smaller left valve. Right valve overlaps left around entire margin; overlap most conspicuous on venter, slightly less conspicuous on dorsum; posterio-ventral overlap comparatively weak with anterio overlap least developed. Dorsal outline of both valves smoothly and broadly convex; ventral outline of right valve much less convex; ventral outline of left valve nearly straight; anterior outline of both valves well rounded; posterior outline of both valves rounded except for slight angulation near mid-height. Greatest height slightly posterior of mid-length; greatest thickness somewhat posterior of mid-length; surface broadly convex except for abrupt slope at posterior. Surface smooth.

Dimensions of type specimen: length, .90 mm.; height, .60 mm.; thickness, .45 mm.

Locality C2.

Holotype, Walker Museum, No. 44474.

Remarks: This species is very similar to *C. coryelli* from the Golconda formation, but *C. ovalis* may be distinguished from that species by its stronger overlap, especially on the venter, by its more rounded dorsal outline, and by its more flattened ventral outline.

Cavellina ? perplexa Croneis and Funkhouser, n. sp.

Plate IX, figs. 19–20

Carapace subovate in outline, medium sized; right valve flanged to receive smaller left valve. Right valve overlaps left valve except at posterior extremity; ventral overlap somewhat stronger than dorsal overlap; posterio-ventral overlap tapers out half way to mid-height; posterio-dorsal overlap tapers out half way to mid-height; anterior overlap slight. Dorsal outline of both valves broadly convex; ventral outline of both valves slightly convex; anterior well rounded; posterior sharply convex. Greatest height slightly posterior of mid-length; greatest thickness near posterior with flat slope toward the anterior. Surface irregularly roughened.

Dimensions of type specimen: length, .80 mm.; height, .57 mm.; thickness, .30 mm.

Locality C1.

Holotype, Walker Museum, No. 44475.

Remarks: This species has been referred to the genus *Cavellina* with some hesitancy; it may be distinguished from *C. ovalis* from the Clore formation by its lack of posterior overlap, and by its relative thinness in respect to its other dimensions.

CLORE LOCALITY INDEX (ILLINOIS)

Notations, This Paper	*Illinois Geological Survey Register Notations*		*Geographic Locations*
Locality C1	0619.20	P 71-4	Clore limestone and shale in ravine north of road one mile east of Whiteside School, Johnson County

Notations, This Paper	*Register Notations*		*Geographic Locations*
Locality C2	0311.73	P 15-Sp. A	Clore shale, gray, sandy and fossiliferous near bottom, exposed in road cut south of Loves Store, 700 feet north of Philadelphia School, Hardin County
Locality C3	0619.20	No. 4	Clore formation, essentially same location as C1.
Locality C4	05A19.06	25 (A)	Clore formation, along road and Whiteside Branch of Hayes Creek 4 miles east and ½ mile north of Glendale, Pope County

BIBLIOGRAPHY

Bassler, R. S., and Kellett, Betty, "Bibliographic Index of Paleozoic Ostracoda," *Geological Society of America, Special Papers*, No. 1, (1934). This index is arranged by periods and formations as well as by species All references to ostracode papers published prior to January 1, 1934 are included in it.

Cooper, C. L., "Ammonium Chloride Sublimate Apparatus," *Journal of Paleontology*, Vol. 9 (1935), No. 4, pp. 357–359.

Coryell, H. N., and Williamson, Marjorie, "Ostracode Fauna of the Waldron Shale," *American Museum of Natural History*, No. 870 (1936), pp. 1–7.

Croneis, Carey, and Gale, Arthur S., Jr., "New Ostracodes from the Golconda Formation," Den. Univ. Bull., Jour. Sci. Lab., Vol. XXXIII, Dec. 1938.

Croneis, Carey, and Thurman, Franklin A., "New Ostracodes from the Kinkaid Formation," Den. Univ. Bull., Jour. Sci. Lab., Vol. XXXIII, Dec. 1938.

Harris, R. W., and Worrell, Frank, "A Fossiliferous Horizon from the Lower Permian of Caddo County, Oklahoma," *Journal of Paleontology*, Vol. 10 (1936), No. 6, pp. 518–519.

Kellett, Betty, "Ostracodes of the Upper Pennsylvanian and the Lower Permian of Kansas," *Journal of Paleontology*, Vol. 9 (1935), No. 2, pp. 132–166.

———, "Carboniferous Ostracodes," *Journal of Paleontology*, Vol. 10 (1936), No. 8, pp. 760–784.

Morey, P. S., "Mississippian Ostracoda from Missouri," *Journal of Paleontology*, Vol. 9 (1935), No. 4, pp. 316–326.

———, "Ostracoda from the Amsden Formation of Wyoming," *Journal of Paleontology*, Vol. (1935), No. 6, pp. 474–482.

———, "Ostracoda from the Chouteau Formation of Missouri," *Journal of Paleontology*, Vol. 10 (1936), No. 2, pp. 114–122.

Payne, K. A., "Pennsylvania Ostracoda from Sullivan County, Indiana," *Journal of Paleontology*, Vol. 11 (1937), No. 4, pp. 276–288.

Roundy, P. V., Girty, G. H., and Goldman, M. I., "Mississippian Formations of San Saba County, Texas," U. S. Geol. Surv., Prof. Paper 146 (1926), pp. 5–17.

Weller, Stuart, "Geology of Hardin County," *Illinois State Geological Survey*, Bulletin 41 (1920), pp. 212–216.

PLATES

EXPLANATION OF PLATE IX

(All figures are of holotypes; magnifications are approximations accurate to within 4 percent.)

Figs. 1–2. *Carboprimitia depressa* Croneis and Funkhouser, n. gen., n. sp.; fig. 1, left valve, ×35; fig. 2, dorsal view, ×35.

Figs. 3–4. *Carboprimitia rotunda* Croneis and Funkhouser, n. sp.; fig. 3, left valve, ×35; fig. 4, dorsal view, ×35.

Figs. 5–6. *Carboprimitia rotunda* var. *tumida* Croneis and Funkhouser, n. var.; fig. 5, left valve, ×35; fig. 6, dorsal view, ×35.

Figs. 7–8. *Sansabella harrisi* Croneis and Funkhouser, n. sp.; fig. 7, left valve, ×50; fig. 8, dorsal view, ×50.

Figs. 9–10. *Cavellina ovalis* Croneis and Funkhouser, n. sp.; fig. 9, left valve, ×35; fig. 10, dorsal view, ×35.

Figs. 11–12. *Lamarella thurmani* Croneis and Funkhouser, n. gen., n. sp.; fig. 11, left valve, ×50; fig. 12, dorsal view, ×50.

Figs. 13–14. *Bairdiolites ovatus* Croneis and Funkhouser, n. sp.; fig. 13, right valve, ×50; fig. 14, dorsal view, ×50.

Fig. 15. *Hollinella* sp.; right valve, ×35.

Figs. 16–17. *Bairdiolites elongatus* Croneis and Funkhouser, n. sp.; fig. 16, right valve, ×50; fig. 17, ventral view, ×50.

Fig. 18. *Deloia sulcata* Croneis and Funkhouser, n. sp.; right valve, ×50.

Figs. 19–20. *Cavellina ? perplexa* Croneis and Funkhouser, n. sp.; fig. 19, dorsal view, ×50; fig. 20, left valve, ×50.

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EXPLANATION OF PLATE X

(All figures are of holotypes; magnifications are approximations accurate to within 4 percent.)

Fig. 1. *Glyptopleura symmetrica* Croneis and Funkhouser, n. sp.; left valve, ×35.
Fig. 2. *Glyptopleura complexa* Croneis and Funkhouser, n. sp.; left valve, ×50.
Fig. 3. *Glyptopleura alata* Croneis and Funkhouser, n. sp.; right valve, ×35.
Fig. 4. *Glyptopleura similis* Croneis and Funkhouser, n. sp.; left valve, ×35.
Figs. 5–6. *Glyptopleura varians* Croneis and Funkhouser, n. sp.; fig. 5, left valve, ×50; fig. 6, dorsal view, ×50.
Fig. 7. *Glyptopleura alternata* Croneis and Funkhouser, n. sp.; left valve, ×35.
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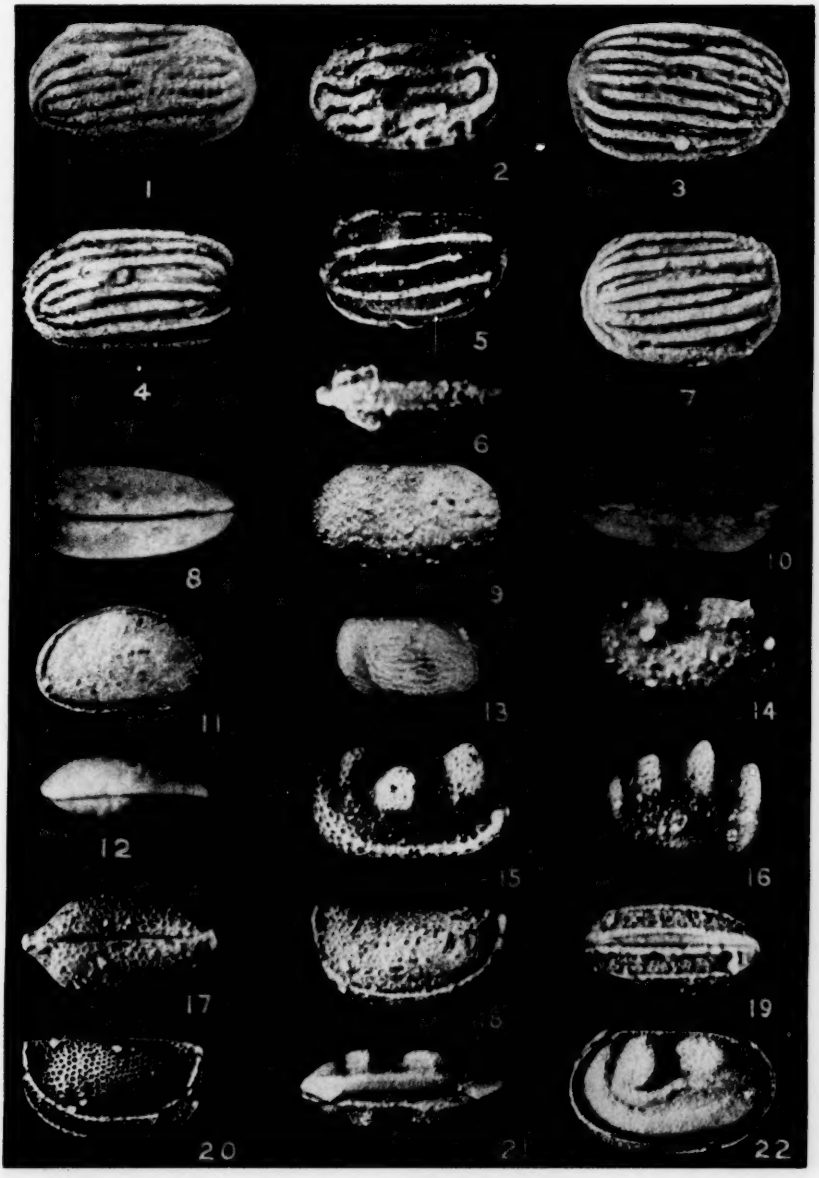
Fig. 13. *Primitiopsis ? striatus* Croneis and Funkhouser, n. sp.; right valve, ×50.
Fig. 14. *Jonesina spinosa* Croneis and Funkhouser, n. sp.; right valve, ×50.
Fig. 15. *Amphissites rothi* Croneis and Funkhouser, n. sp.; right valve, ×50.
Fig. 16. *Balantoides moreyi* Croneis and Funkhouser, n. sp.; right valve, ×50.
Figs. 17–19. *Kirkbya aequalis* Croneis and Funkhouser, n. sp.; fig. 17, dorsal view, ×50; fig. 18, right valve, ×50; fig. 19, ventral view, ×50.
Fig. 20. *Kirkbya marginata* Croneis and Funkhouser, n. sp.; right valve, ×35.
Figs. 21–22. *Jonesina insculpta* Croneis and Funkhouser, n. sp.; fig. 21, dorsal view, ×35; fig. 22, right valve, ×35.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